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Subject: Algorithms and Specifications for Data Reduction and Analysis Program (DRAP)

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ABSTRACT

One of the major systems in NASA's Mission Control Center - Houston is the Display/Control System. This computer-based system provides displays and control capability for over sixty consoles manned by Flight Controllers. All of the control inputs and display requests originating at these consoles, plus automatically generated equipment status reports, are logged on magnetic tape as they enter the computer. In addition, all of the display and other outputs from the computer are similarly logged. After pre-processing, the logged data can be used to perform various analyses of loading and performance for the display system, such as the distribution of various types of requests and their interarrival times, the degree to which the shared display-generation equipment is saturated by demand, the availability of this equipment as determined by malfunctions, the distribution of response times of the computer to display requests, and the utilization of available display formats by the various console operators.

Data Reduction and Analysis Program (DRAP) is a software package which performs such analyses, using pre-processed logged data as input. The algorithms and gross specifications for six component modules of DRAP are presented. In a report to be published later, the results of applying DRAP are presented. In a report to be published later, the results of applying DRAP to the logged data from five GEMINI and one APOLLO mission will be presented.

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SECTION I

INTRODUCTION

The MITRE Corporation began technical support activities for NASA's Manned Spacecraft Center (MSC) in Houston, in January, 1966. Out of the initial work (a four-month study) came a number of techniques (referred to hereafter as "analyses") for analyzing the employment (by Flight Controllers) and the performance of that part of the Mission Control Center - Houston (MCC-H) known as the Display/Control System (D/C System). These analyses were essentially techniques for analyzing certain data automatically recorded during each mission (or simulated mission) controlled at MCC-H, so as to produce summary data and quantities (time histories, statistical descriptions, average values, maximum/minimum values, etc.) descriptive of D/C System performance and employment. The quantities produced by these analyses thus have the nature of measures of performance in some cases; in other cases, they may be viewed as <u>components</u> of performance measures. In some cases the results are measures of <u>utilization</u> (of system resources) during a mission. In each case, the analyses define quantities of interest, and tell how these may be computed from the automatically recorded data.

The nature of the analyses was heavily dependent on the nature of available data to be used as a starting point. This data, known as "log data", consisted of all inputs to, and outputs from, the computer which interfaced with the D/C System. As each input arrived at the computer, it was automatically logged, together with the time, on a log tape, and likewise for the outputs from the computer. The result was a number of reels (20 to 45 for the later GEMINI missions) of magnetic tape, containing, essentially, raw data; no attempt was made during the logging process to sort the data in any way other than by time of occurrence. At the time of initial development of the analyses (some of the results of applying these to the GEMINI - VIII mission are reported in MTR-1202, Volume IV) there was in existence a Philco program called DRIP which could be used to pre-process the log data so that only the desired pieces of data were interpreted and printed out in a report. It was by manual procedures (including use of desk calculators) that the original analyses were done, using stacks of DRIP printout as a starting point.

Because of the tedious and time-consuming nature of the manually-done analyses, it seemed desirable to automate (computerize) the process. The first step was to describe precisely the steps and calculations involved in each analysis, including the type of pre-processed (DRIP) data needed as input to the analysis, and the types of summary quantities produces as outputs of the analysis. In addition to this "algorithmetization" of each analysis, various practical constraints related to bounds on numbers to be computed and amount of storage required, had to be considered before specifying a program to do the analysis. The resulting document in each case, although titled an "algorithm", was not limited to computational algorithms. Indeed, most of the computations are simple arithmetic ones such as addition, division, etc. Neither was the document a complete program specification, in the usual sense, although it contained elements of a program specification.

Six of these "algorithms" have been produced to date, each one intended to serve as the starting point for a computer program, or program module. The programming of these modules has been done by Philco personnel, and the resulting package of programs is known as DRAP (Data

Reduction and Analysis Program). The purpose of this document is to collect, in one place, all of the MITRE-produced algorithms for DRAP modules 1 through 6. These vary somewhat in level of detail; this is partly accounted for by the fact that many detailed techniques and procedures were worked out and agreed to verbally between Philco and MITRE personnel.

A document subsequent to this one is planned, in which results of running DRAP against data from four GEMINI and one APOLLO missions will be given. Some of these results (for DRAP 1 and 2) have already been reported in MTR-1204.

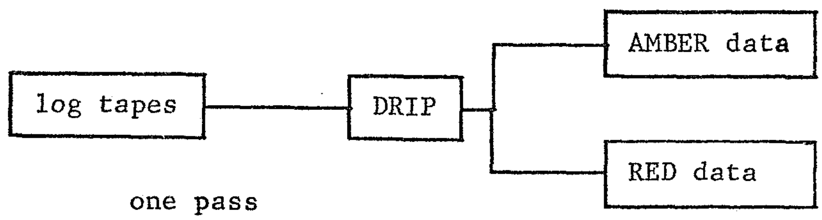
NOTE: Although compiled in one document, the six algorithms presented here were developed at different times and thus each section of this report stands alone. There is no cross-referencing between sections of tables, figures or information. Thus, tables and figures in each section are numbered consecutively starting with Arabic numeral 1. A reference in the text to Figure 1, simply means the first figure within the section where the reference appears. Considerable production time and effort has been saved by not changing the numbering scheme. It is hoped that the reader will not find this a serious deterrent to reading and comprehension.

SECTION II

ALGORITHM FOR RED/AMBER ANALYSIS

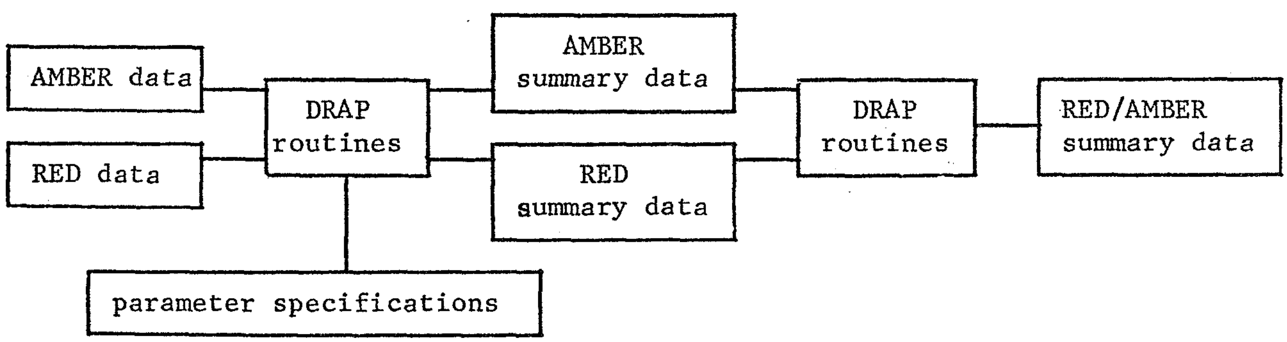
1. Required DRIP Input

The DRIP Report 8 is to yield ON and OFF times (GMT) for two selected bits (event lights), e.g., set address 0600, bits 12 (AMBER condition) and 13 (RED condition):



2. Operation of DRAP Routines

Each of the two sets of data is to be operated upon by the same DRAP routines to yield two sets of summary data: AMBER summary data and RED summary data. In addition, other DRAP routines will operate on both RED and AMBER summary data to produce RED/AMBER summary data.



All summary data will be printed out, along with some of the parameters specified and header information. Parameter specifications are input to DRAP along with the AMBER data and RED data. Since the DRAP routines operate in identical fashion on the AMBER data and RED data, the algorithms for this part of the analysis will be described once, in Section 3, along with the pertinent parameter specifications. The algorithms and parameter specifications for those DRAP routines which operate on RED summary data and AMBER summary data are described in Section 4. A suggested DRAP report format is given in Section 5.

3. Algorithms for Producing RED (or AMBER) Summary Data

These algorithms produce RED summary data (or AMBER summary data) of two types: time history data (algorithms described in 3.1) and statistical distribution data (algorithms described in 3.2).

3.1 Time History Summary Data

The object is to produce calculated quantities for each of a number of contiguous time intervals, so that the quantities can be plotted versus time interval to yield time histories.

3.1.1 Input Parameters

Input parameters which must be specified for these calculations are:

(1) GMT_s, the time during the mission at which the analysis is to start, and GMT_f, a mission time before which the analysis is to finish. Most, but not all, ON and OFF times between these limits are used in the calculations.

(2) T, the duration in seconds of each time interval. T may vary from 60 to 24,000 seconds.

3.1.2 Set-Up Calculations and Designations

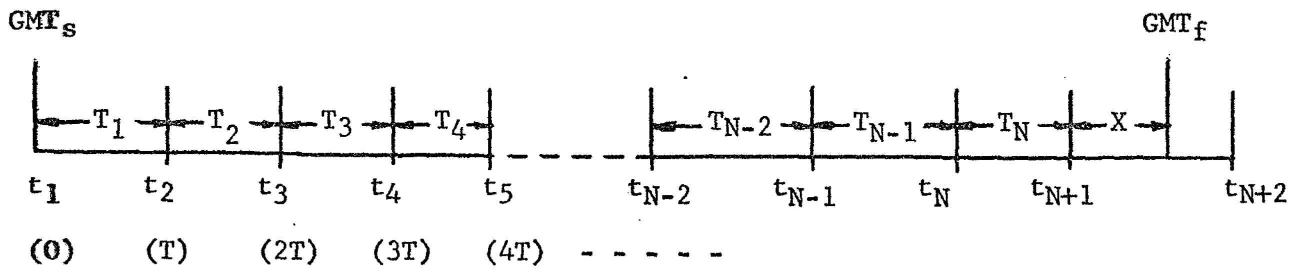
(1) Set up two storage areas for storing two types of durations. In one of these, the "distribution bin", are stored all "complete" durations, irrespective of which time interval

they fall in (see below); the contents of this bin serve as data for the calculations of Section 3.2. In the other, the "interval bin", are stored all durations associated with a given interval. The interval associated with this latter bin changes as the analysis proceeds through the various time intervals.

(2) GMT_s and t_1, the start of the first time interval, are synonymous insofar as relating analysis time to mission time. However, the value assumed for t_1 in the analysis is zero. Hence all calculated and printed-out values of t are <u>relative</u> values (relative to GMT_s), and must be added to GMT_s if one wishes to obtain GMT mission times. The first interval will be referred to as T_1, the second as T_2, etc.

(3) Calculate $t_2 = t_1 + T$, the end of the first interval T_1 and the beginning of the second interval T_2. Note t_2 will equal T.

(4) Continue calculating the break points between intervals, using $t_1 = t_{i-1} + T$ or $t_i = (i-1)T$. Continue until a $t_i \geq GMT_f$ results; the value of i when this happens is N+2, where N is the number of intervals (N is to be printed out). Thus t_N is the start, and t_{N+1} the end, of the last (or N^{th}) interval to be used in the analysis. This last interval will usually not extend as far as the mission time GMT_f specified in 3.1.1, and the data between t_{N+1} and GMT_f (denoted by X below) is not to be used.

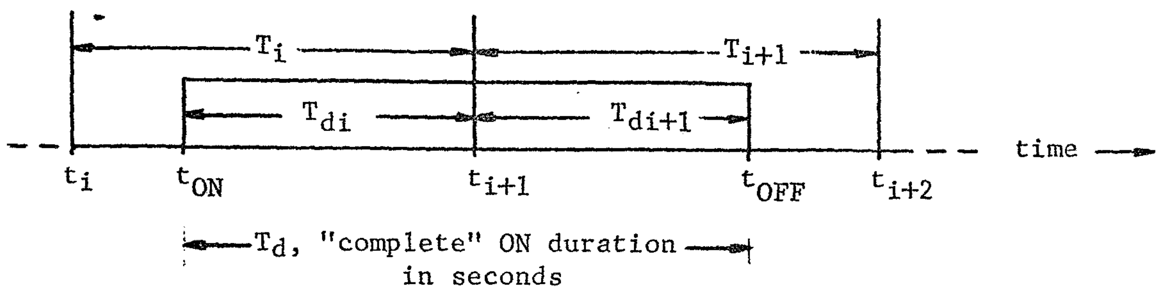


3.1.3 Calculation of Durations

The ON durations of the light (or "true" durations of the associated bit) are to be calculated by subtracting each OFF time t_{OFF} from the preceding ON time, t_{ON}, thus producing an ON duration T_d, in seconds. These ON durations are to be calculated for each time interval T_i, i = 1, 2, ---, N. These individual durations are stored in the interval bin.

The durations associated with each interval are counted to obtain C, the number of durations in that interval, and are summed to obtain D, the total ON time in that interval. The numbers C_i and D_i associated with the i^{th} interval are printed out, along with i and t_i.

As long as all durations fall completely within an interval, the above procedure is straightforward. Such durations are stored in the interval bin; in addition, they, and all others which represent total true durations, will be called "complete" durations and are stored in the distribution bin. When a duration overlaps two or more intervals, it is necessary to compute both the "complete" duration (end-to-end length) and two or more "split" durations (representing the portions of the duration which lie in different intervals). The situation is shown below for a duration overlapping two intervals.



The above situation arises when one or more interval boundaries (such as t_{i+1}) fall between successive ON and OFF times. If such boundaries fall between successive OFF and ON times, no problem arises. A "split procedure" is described below for use in cases of overlap, with reference to the preceding diagram.

(1) Calculate the first "split" duration T_{di} by

$$T_{di} = t_{i+1} - t_{ON} ,$$

and store this in the interval bin for interval i, as well as in an accumulator.

(2) When all complete durations for T_i have been stored in the distribution bin, and all complete and all split durations for T_i have been stored in the interval bin, count and sum the intervals in the interval bin (interval = i) and store or print the results C_i and D_i. Increment i to i+1 and calculate the second split duration T_{di+1} by

$$T_{di+1} = t_{OFF} - t_{i+1} ,$$

storing this in the interval bin (now for interval i+1) and adding it to the contents of the accumulator to obtain the complete duration $T_d = T_{di} + T_{di+1}$, which is stored in the distribution bin. Complete the calculations for T_{i+1}, including a split duration procedure at the end of this interval, if necessary.

(3) For durations overlapping more than two intervals, continue the above procedure. The last addition to the accumulator will occur when one reaches an interval containing a t_{OFF}. For an interval completely overlapped by a duration, T_{di} will have the value $t_{i+1} - t_i = T$.

When all intervals have been examined, the result should be a set of C_i and D_i which have been printed out from the interval bin, along with corresponding values of i and t_i. Also, a set of complete durations T_d will have been accumulated in the distribution bin, to be used in the calculations of Section 3.2.

Since calculations and comparisons will be done which involve the t_i (analysis time, or relative time, with GMT_s as reference) and t_{ON}, t_{OFF} (delivered as GMT mission time by DRIP), some sort of conversion of one or the other types of time will have to be made. It may be easier to convert the t_{ON} and T_{OFF} GMT times to analysis time, by subtracting GMT_s from each one, than to convert the t_i to GMT times. Also, the times printed out as part of the additional header information (see Section 5.1) should be given both in GMT notation and in terms of analysis time. Note that in all times to be calculated or printed out, the number of seconds is to be rounded off to the nearest whole second.

3.2 Statistical Distribution Summary Data

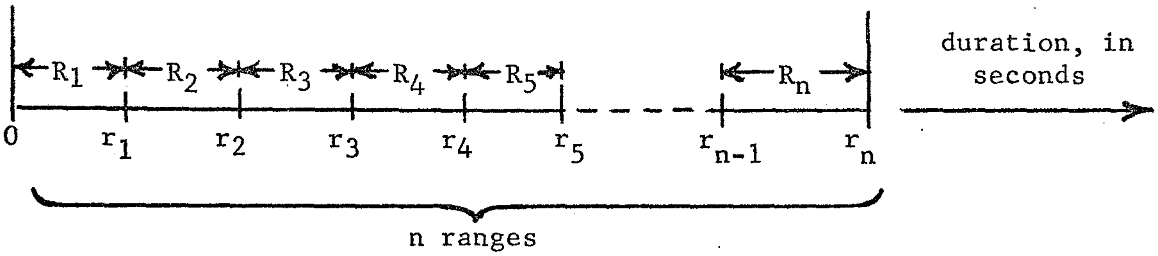
Using the complete durations stored in the distribution bin, it is desired to calculate points for a histogram and for a cumulative distribution of durations.

3.2.1 Input Parameters

The one input parameter which must be specified for these calculations is the length of the histogram range, R. This is a number of seconds, which may vary from 1 to 100.

3.2.2 Set-Up Calculations and Designations

The abscissa (horizontal) axis of the histogram will be divided into n contiguous and equal ranges, each of length R seconds, as shown below.



$$R_j = R \text{ for } j = 1, 2, ---, n$$

The number of ranges is determined as follows:

(1) From the set of all complete durations stored in the distribution bin, select the largest (if there are two "largest" durations, use their common value, etc.), and call this T_{dmax}. Print out T_{dmax}.

(2) Compute

$$\frac{T_{dmax}}{R}$$

and round this off to the next larger integer. This next larger integer is n, the number of ranges. Print out n.

Calculate the break-points between ranges, i.e., calculate r_1, r_2, ---, r_n (the first range always starts at 0).

$$r_j = r_{j-1} + R = (j)(R), \; j = 1, 2, ---, n.$$

3.2.3 Calculation of Distribution Quantities

In order to obtain quantities for a histogram, the durations in the distribution bin are to be sorted and allotted to the various ranges. A particular duration T_d is allotted to range R_j if

$$r_{j-1} < T_d \leq r_j .$$

When the allocation is completed for each range, the durations in that range are counted, and this count designated by c_j for the j^{th} range. (Alternatively, the count could be accumulated during the allotment procedure.)

Also calculated is the sum S_D of all durations in the distribution bin and a count M of the number of these durations, where

$$S_D = \sum_{\substack{\text{distr.} \\ \text{bin}}} T_d \qquad \text{and} \qquad M = \sum_{j=1}^{n} c_j .$$

Also calculated is the mean duration $\bar{D}$, where

$\bar{D} = \frac{S_D}{M}$, and the total duration as a percent of mission time analyzed:

$$L = \frac{100 S_D}{NT}$$

Also calculated is p_j, the percent of the durations which fell in the j^{th} range:

$$p_j = \frac{100 c_j}{M}$$

Single quantities to be printed out are S_D, M, L, and $\bar{D}$. A set of range-dependent quantities c_j and p_j, accompanied by corresponding values of j and r_j, are printed out for j = 1, 2, ---

---, n.

In order to obtain points for a cummulative distribution of durations, the quantites

$$A_k = \sum_{j=1}^{k} c_j$$

and

$$F_k = \frac{100A_k}{M}$$

are calculated for k = 1, 2, ---, n. These are printed out with the corresponding values of k and r_k, where $r_k = (k)(R)$.

4. Algorithms for Producing RED/AMBER Summary Data

Using the RED summary data and the AMBER summary data produced by the algorithms of Section 3, it is desired to combine some of these quantities to obtain RED/AMBER summary data, as described below in two categories (Sections 4.1 and 4.2).

4.1 Time History RED/AMBER Summary Data

The object here is the same as that of Section 3.1, except the quantities to be plotted are for both RED and AMBER (logically, RED <u>or</u> AMBER).

4.1.1 Input Parameters

These are the same as in Section 3.1.1, hence they will already be available.

4.1.2 Set-Up Calculations and Designations

One of these (calculation of the t_i) will have already been done, as in Section 3.1.2. Make a further definition as follows:

The set of quantities D_i will have been calculated (Section 3.1.3) for RED, and again for AMBER. Identify these by D_{iR} and D_{iA}, $i = 1, 2, ---, N$.

4.1.3 Calculation of RED/AMBER Durations

Add D_{iR} and D_{iA} for each value of i, to obtain a set of D_{iRA}. Print out these N numbers, along with their associated values of i and t_i.

4.2 Statistical Distribution RED/AMBER Summary Data

The object here is the same as for Section 3.2, except that the quantities to be plotted are for both RED and AMBER (logically, RED or AMBER).

4.2.1 Input Parameters

These are the same as in Section 3.2.1, hence they will already be available.

4.2.2 Set-Up Calculations and Designations

Some of these (calculation of the r_j and n) will already have been done, as in Section 3.2.2. Make further definitions as follows:

The set of quantities c_j will have been calculated (Section 3.2.3) for RED, and again for AMBER. Call these c_{jR} and c_{jA}. Also, n will have been calculated for RED and for AMBER; call these two values n_R and n_A. In general, n_R will not be equal to n_A; choose the larger of these for use in the following calculations and call it n_{RA}.

Along with each of the two previous values of n there will have been calculated a set of break-points between ranges:

$$r_{jR},\ j = 1, 2, ---, n_R, \text{ and}$$

$$r_{jA},\ j = 1, 2, ---, n_A.$$

Use the set of r_j corresponding to the value of n chosen above (i.e., if n_A is larger than n_R, choose n_{RA} equal to n_A and use the r_{jA}).

Also previously calculated (see Section 3.2.3) will be S_D and M for both RED and AMBER, i.e., S_{DR}, S_{DA}, M_R, and M_A. Likewise, quantities p_{jR} and p_{jA}, A_{kR} and A_{kA}, F_{kR} and F_{kA} will have been computed.

4.2.3 Calculation of Distribution Quantities

Compute points for a RED/AMBER histogram by adding c_{jR} to c_{jA} for each value of j, and call the resulting numbers c_{jRA}. Print out the n_{RA} values of c_{jRA}, along with their associated values of j and r_j.

Also compute

$$S_{DRA} = S_{DR} + S_{DA} ,$$

$$M_{RA} = M_R + M_A ,$$

$$\bar{D}_{RA} = \frac{S_{DRA}}{M_{RA}} ,$$

$$L_{RA} = L_R + L_A ,$$

and print out (as a check, note that S_{DRA} should equal $\sum_{i=1}^{n} D_{iRA}$).

Also, compute the set of quantities

$$p_{jRA} = \frac{100\ c_{jRA}}{M_{RA}} ,\ j = 1, 2, ---, n_{RA},$$

and print out, along with the corresponding values of j and r_j.

In order to obtain points for a cumulative distribution of RED/AMBER durations, the quantities

$$A_{kRA} = A_{kR} + A_{kA} \ ,$$

$$F_{kRA} = \frac{100A_{RA}}{M_{RA}} \ , \text{and}$$

$$r_k = (k)(R)$$

all for k = 1, 2, ---, n_{RA}, are computed and printed out, along with corresponding values of k.

5. Output Format

A suggested DRAP output report format is given below. The blanks are to be filled with information supplied as part of the parameter specifications, and with computed summary data.

5.1 Header Information

Data Retrieval and Analysis Program (DRAP)

DRAP Module 1 Report - RED/AMBER Analysis

(mission, e.g. GT-8, AS204, etc.) GMT_s_____ GMT_f_____

Set Address __________ Lamp Control bits___ and _____

RED(bit__) is __ to __ channels in use.

AMBER (bit__) is __ to __ channels in use.

(Additional header information to be supplied for each run, generally having the following format

	GMT Mission Time	Analysis Time
Start of Pre-Launch 1	____________	____________
Start of Agena Launch	____________	____________
Start of Pre-Launch 2	____________	____________
Start of GEMINI Launch	____________	____________
Start of Orbital	____________	____________
Start of Re-Entry	____________	____________
Splash Down	____________	____________

Other Event Times

________	________	________
________	________	________
________	________	________
________	________	________
________	________	________
________	________	________

5.2 Data Format

RED Summary Data

T = ____________ seconds R = __________ seconds

t_1 = ____________ GMT T_{dmax} = __________ seconds

N = ____________ n = __________

i	t_i	C_i	D_i	j	r_j	c_j	p_j
1	t_1	C_1	D_1	1	r_1	c_1	p_1
2	t_2	C_2	D_2	2	r_2	c_2	p_2
3	t_3	C_3	D_3	3	r_3	c_3	p_3
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	n	r_n	c_N	p_N
.	.	.	.				
N	t_N	C_N	D_N				

S_D = __________ seconds $\bar{D}$ = __________ seconds

M = __________ occurrences L = __________ percent

k	r_k	A_k	F_k
1	r_1	A_1	F_1
2	r_2	A_2	F_2
.	.	.	.
.	.	.	.
.	.	.	.
n	r_n	A_n	F_n

AMBER Summary Data

(same as above for RED)

RED/AMBER Summary Data

i	t_i	D_{iRA}
1	t_1	D_1
2	t_2	D_2
.	.	.
.	.	.
.	.	.
.	.	.
.	.	.
N	t_N	D_N

j	r_j	c_{jRA}	p_{jRA}
1	r_1	c_1	p_1
2	r_2	c_2	p_2
.	.	.	.
.	.	.	.
.	.	.	.
n_{RA}	r_{nRA}	c_{nRA}	p_{nRA}

S_{DRA} = ____________ seconds $\bar{D}_{RA}$ = __________ seconds

M_{RA} = ____________ occurrences L_{RA} = __________ percent

k	r_k	A_{kRA}	F_{kRA}
1	r_1	A_1	F_1
2	r_2	A_2	F_2
.	.	.	.
.	.	.	.
.	.	.	.
.	.	.	.
n_{RA}	r_{nRA}	A_{nRA}	F_{nRA}

SECTION III

ALGORITHM FOR D/TV OUTAGE ANALYSIS

1. Required DRIP Input

The DRIP Report 1 (for any console) yields a history of ESW reports on the status of the D/TV and Reference File channels, each identified by GMT time of occurrence. Only the ESW's concerning D/TV channels are to be used.

2. Operation of DRAP Routines

DRAP routines operate on the D/TV channel status data to produce two types of summary data: outage statistics on each individual channel; and availability statistics (in terms of how many channels are simultaneously out and for how long) for the system as a whole. Because of the nature of ESW reports, it is necessary to compare each one with the previous one in order to properly interpret them.

The only input parameter which must be specified for DRAP is N, the number of D/TV channels for which log data is recorded (N = 28 for missions GT-8 through GT-11, but may change for future missions). A block of log tape data will previously have been specified for DRIP in terms of an "Initial Time" and a "Final Time"; only ESW's between these times will be examined by DRAP. When the first ESW examined is anything other than a "NO D/TV CHAN OUT", a special assumption will have to be made, since no previous ESW is available for comparison; likewise, certain information in the last ESW examined may have to be discarded, since no following ESW is available (See Section 6).

3. Interpretation of ESW Data

Table I shows a hypothetical sequence of D/TV ESW's (suitably abbreviated) as they would appear on DRIP printout. Also shown are interpretations of the ESW's, and the two notations used for designating time. The table as a whole represents a single continuous sequence of ESW's, but is divided into two somewhat different parts, for convenience in later discussion.

In the first column of the table, the GMT's are mission times as reported by DRIP. These must be converted into "analysis times" in seconds, so that arithmetic operations can be performed on them. It is permissible to express these times as relative times (relative to GMT_1) as long as these can be related back to GMT. Printed-out times, other than GMT's, should be rounded to the nearest second. GMT_1 (or t_1) is the time of the first ESW examined, and the start of the analysis; it must be saved for use in one of the final calculations at the end of the analysis. It must also be printed out, both in GMT and seconds. The "status time" notation is purely for convenience in describing the calculations; each status time is equal to one of the analysis times (the reverse is not true, as for t_{11}).

Note that DRAP, in interpreting a particular ESW, must have the previous ESW for comparison.

A graphical interpretation of the first part of Table I (through t_9) is shown in Figure 1. The time notation here corresponds to Table I: the status times are times when the status of an individual channel

TABLE I

DRIP DATA (abbreviated)	ANALYSIS TIMES	INTERPRETATION	STATUS TIMES
GMT_1 NO CHAN OUT	t_1	All Channels are "IN"	none
GMT_2 CHAN OUT 8	t_2	At GMT_2, channel 8 went OUT (first status change for this channel)	t_{81}
GMT_3 NO CHAN OUT	t_3	At GMT_3, channel 8 went IN (second status change for this channel)	t_{82}
GMT_4 CHAN OUT 5	t_4	At GMT_4, channel 5 went OUT (first status change for this channel)	t_{51}
GMT_5 CHAN OUT 5 7	t_5	At GMT_5, channel 7 went OUT (first status change for this channel)	t_{71}
GMT_6 CHAN OUT 5 7 8	t_6	At GMT_6, channel 8 went OUT (third status change for this channel)	t_{83}
GMT_7 CHAN OUT 7 8	t_7	At GMT_7, channel 5 went IN (second status change for this channel)	t_{52}
GMT_8 CHAN OUT 7	t_8	At GMT_8, channel 8 went IN (fourth status change for this channel)	t_{84}
GMT_9 NO CHAN OUT	t_9	At GMT_9, channel 7 went IN (second status change for this channel)	t_{72}

continued.....

TABLE I (continued)

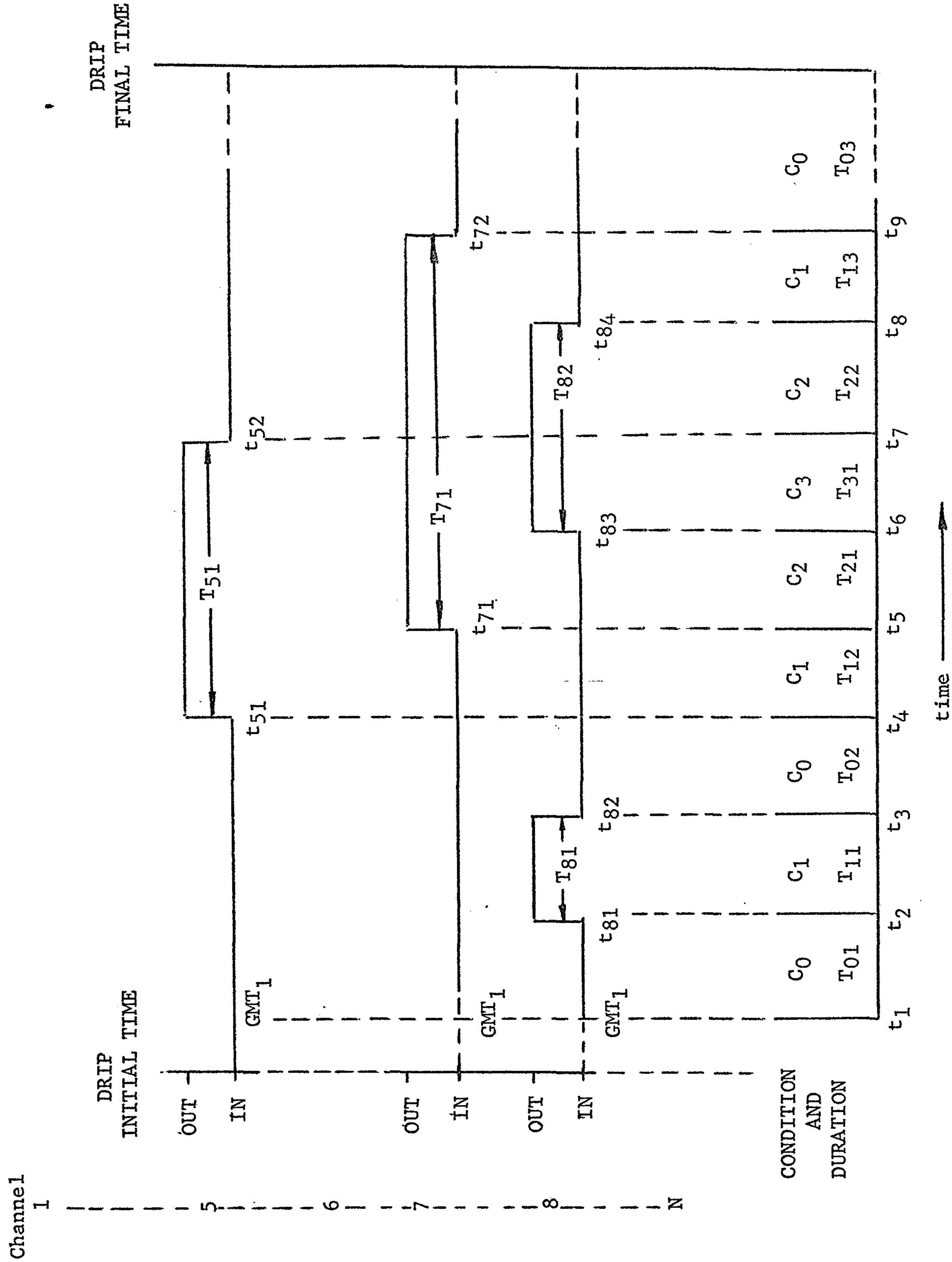
DRIP DATA (abbreviated)	ANALYSIS TIMES	INTERPRETATION	STATUS TIMES
GMT_{10} CHAN OUT 3	t_{10}	At t_{10}, Channel 3 went OUT (status change, condition change)	t_{31}
GMT_{11} CHAN OUT 3	t_{11}	At t_{11}, Identical to previous ESW (no status change, no condition change)	none
GMT_{12} CHAN OUT 3 5 6	t_{12}	At t_{12}, Channels 5 and 6 went OUT (status changes, condition change)	t_{53}, t_{61}
GMT_{13} CHAN OUT 3 5	t_{13}	At t_{13}, Channel 6 went IN (status change, condition change)	t_{62}
GMT_{14} CHAN OUT 3	t_{14}	At t_{14}, Channel 5 went IN (status change, condition change)	t_{54}
GMT_{15} CHAN OUT 7 9	t_{15}	At t_{15}, Channel 3 went IN, 7 and 9 went OUT (status changes, condition change)	t_{32}, t_{73}, t_{91}
GMT_{16} CHAN OUT 1 2	t_{16}	At t_{16}, Channels 7 & 9 went IN, 1 & 2 went OUT (status changes, no condition change)	t_{74}, t_{92}, t_{11}, t_{21}
GMT_{17} NO CHAN OUT	t_{17}	At t_{17}, Channels 1 & 2 went IN (status changes, condition change)	t_{12}, t_{22}
GMT_{18} CHAN OUT 4	t_{18}	At t_{18}, Channel 4 went OUT (status change, condition change	t_{41}

changes, and the analysis times are simply another way of representing the GMT times-of-occurrence of ESW's. In addition, the outage durations of particular channels are represented by T_{ij}, where i = 1, 2, ---, N is channel number and j = 1, 2, ---, n_i is an index representing the order of occurrence of outage durations for a given channel (n_i is the total number of outages for the i^{th} channel). Also, the sequence of conditions C_i and condition durations T_{ik} is shown for the system as a whole; here i = 0, 1, 2, ---, N is the number of channels simultaneously OUT, and k = 1, 2, ---, K_i is an index representing the order of occurrence of condition durations for a given condition. Since K_i is the total number of occurrences of C_i, it is expected to be zero for values of i greater than about 5 (no more than 3 simultaneous channel outages have been observed for GT-8, 9, and 10). Likewise, K_0 is likely to be larger than any other K_i. As an example, Figure 1 shows that two occurrences of the C_2 condition (2 channels simultaneously out) occurred in this time frame, their durations were T_{21} and T_{22}. Note that the subscript i does not have the same meaning or range for T_{ij} as it does for T_{ik}.

4. Calculation of Outage Summary Data

For each channel (that is, for i = 1, 2, ---, N) the outage durations T_{ij} are to be calculated, and saved until the end of the analysis, when they are ordered in increasing value (for each channel) and printed out, along with corresponding values of i.

$$T_{i1} = t_{i2} - t_{i1} \tag{1}$$



Channel
1
5
6
7
8
N
DRIP INITIAL TIME
DRIP FINAL TIME
OUT
IN
OUT
IN
OUT
IN
GMT_1
GMT_1
GMT_1
t_{51}
T_{51}
t_{52}
t_{71}
T_{71}
t_{72}
t_{81}
T_{81}
t_{82}
t_{83}
T_{82}
t_{84}
CONDITION AND DURATION
C_0 T_{01}
C_1 T_{11}
C_0 T_{02}
C_1 T_{12}
C_2 T_{21}
C_3 T_{31}
C_2 T_{22}
C_1 T_{13}
C_0 T_{03}
t_1
t_2
t_3
t_4
t_5
t_6
t_7
t_8
t_9
time

FIGURE 1

$$T_{i2} = t_{i4} - t_{i3} \quad (2)$$

$$T_{ij} = t_{i,2j} - t_{i,2j-1} \quad (3)$$

$$T_{in_i} = t_{i,2n_i} - t_{i,2n_i-1} \quad (4)$$

The n_i (total number of outages for the i^{th} channel) are to be accumulated or calculated (as by counting the T_{ij}) for each channel, and then summed to get n_T, the total number of outages in all channels; this is printed out.

$$n_T = \sum_{i=1}^{N} n_i \quad (5)$$

The outage durations are to be summed, for each channel, to give total outage times S_i,

$$S_i = \sum_{j=1}^{n_i} T_{ij} \quad (6)$$

which are printed out. Also, the S_i are summed over all channels to give S_T, the total system outage time, and this is printed out.

$$S_T = \sum_{i=1}^{N} S_i \quad (7)$$

To illustrate the use of the foregoing equations, assume that the first part of Table I (through GMT_9) is a complete set of ESW's to be analyzed, and assume the following values for the GMT's:

GMT_1 = 01/11/ 00' 00.000

GMT_2 = 01/11/ 20' 03.200 = t_{81}

GMT_3 = 01/11/ 20' 56.295 = t_{82}

GMT_4 = 01/16/ 12' 31.314 = t_{51}

GMT_5 = 01/16/ 13' 02.156 = t_{71}

GMT_6 = 01/16/ 14' 20.512 = t_{83}

$GMT_7 = 01/16/\ 15'\ 40.679 = t_{52}$

$GMT_8 = 01/16/\ 16'\ 50.000 = t_{84}$

$GMT_9 = 01/16/\ 17'\ 14.656 = t_{72}$

Although GMT's include thousandths of seconds, these are not significant in the analysis (although they may be in distinguishing between one ESW and the next). In the following, calculated times are shown in both complete form and also rounded to the nearest second (in parentheses).

To continue the example, with reference to Table I and Figure 1, equation (3) yields $T_{ij} = 0$ except for i = 5, 7, and 8:

$T_{51} = t_{52} - t_{51} = 03'\ 9.365$ (or 189 seconds)

$T_{71} = t_{72} - t_{71} = 04'\ 12.500$ (or 253 seconds)

$T_{81} = t_{82} - t_{81} = 00'\ 53.095$ (or 53 seconds)

$T_{82} = t_{84} - t_{83} = 02'\ 29.488$ (or 149 seconds)

Also,

$n_5 = 1, \quad n_7 = 1, \quad n_8 = 2,$

thus equation (5) yields

$n_T = n_5 + n_7 + n_8 = 4.$

Equation (6) yields $S_i = 0$ except for i = 5, 7, and 8:

$S_5 = T_{51} = 03'\ 9.365$ (or 189 seconds)

$S_7 = T_{71} = 04'\ 12.500$ (or 253 seconds)

$S_8 = T_{81} + T_{82} = 03'\ 22.583$ (or 203 seconds)

Equation (7) yields

$S_T = S_5 + S_7 + S_8 = 10'\ 44.448$ (or 644 seconds)

In the above, rounding was done after the calculation, but it is permissible to round all status times and analysis times before calculation (this may be desirable from a machine point of view, since for a fifteen-day mission, some analysis times, even if relative ones, may approach 1.3×10^6 seconds).

5. Calculation of Availability Summary Data

Considering the outage histories for all channels, it is desired to determine for what percent of the total analysis time the system was in each of the possible N + 1 conditions:

C_0 (no channels OUT)

C_1 (1 channel OUT)

C_2 (2 channels OUT)

|

C_N (all N channels OUT)

Thus DRAP must be able to identify all changes in condition (such changes will not necessarily coincide with individual status changes; see GMT_{16} in Table I). One way of doing this would be to set up a "condition counter". The contents of the counter would be incremented (by one) each time a channel went OUT, and decremented (by one) each time a channel went IN. The number in the counter (which would be i) would reflect the current condition of the system.

The condition durations T_{ik} must also be calculated, but this can be done for a given i and k only after the counter contents have been changed, hence the counter contents would have to be saved for at least one cycle if such a scheme were used.

The T_{ik}'s are not easily expressed in general form in terms of either status times or analysis times (i.e., condition will not necessarily change with either a channel status change or a new ESW). They would be easily calculated, however, from knowledge of the times at which the condition counter's contents were changed. To illustrate, Table II below shows the sequence of events if one assumes the sequence of ESW's in Table I (entire table).

TABLE II

ANALYSIS TIME, t_x	CONTENTS OF COUNTER (after t_x)	CONDITION DURATION CALCULATION	SAVE FOR NEXT CALCULATION
t_1	0	none	t_1
t_2	0 + 1 = 1	$T_{01} = t_2 - t_1$	t_2
t_3	1 - 1 = 0	$T_{11} = t_3 - t_2$	t_3
t_4	0 + 1 = 1	$T_{02} = t_4 - t_3$	t_4
t_5	1 + 1 = 2	$T_{12} = t_5 - t_4$	t_5
t_6	2 + 1 = 3	$T_{21} = t_6 - t_5$	t_6
t_7	3 - 1 = 2	$T_{31} = t_7 - t_6$	t_7
t_8	2 - 1 = 1	$T_{22} = t_8 - t_7$	t_8
t_9	1 - 1 = 0	$T_{13} = t_9 - t_8$	t_9
t_{10}	0 + 1 = 1	$T_{03} = t_{10} - t_9$	t_{10}
t_{11}	(no change) 1	none	t_{10}
t_{12}	1 + 1 + 1 = 3	$T_{14} = t_{12} - t_{10}$	t_{12}
t_{13}	3 - 1 = 2	$T_{32} = t_{13} - t_{12}$	t_{13}
t_{14}	2 - 1 = 1	$T_{23} = t_{14} - t_{13}$	t_{14}
t_{15}	1-1+1+1 = 2	$T_{15} = t_{15} - t_{14}$	t_{15}
t_{16}	2-1-1+1+1 = 2	none	t_{15}
t_{17}	2 - 1 - 1 = 0	$T_{24} = t_{17} - t_{15}$	t_{17}
t_{18}	0 + 1 = 1	$T_{04} = t_{18} - t_{17}$	none

Note that a duration calculation is strictly necessary only when the counter contents change, as in Table II; however, a calculation could be made at every t_x (this would simply give more T_{ik}'s to sum, but the sum would be the same). Also, the t_x at a change of condition would be saved for either one cycle or until the next condition change, depending on the technique used.

The condition durations are to be summed, for each value of i, to obtain the total durations D_i of the various conditions.

$$D_0 = \sum_{k=1}^{K_0} T_{0k} \tag{8}$$

$$D_1 = \sum_{k=1}^{K_1} T_{1k} \tag{9}$$

$$D_2 = \sum_{k=1}^{K_2} T_{2k} \tag{10}$$

$$D_i = \sum_{k=1}^{K_i} T_{ik} \tag{11}$$

$$D_N = \sum_{k=1}^{K_N} T_{Nk} \tag{12}$$

These D_i are divided by total analysis time T_a

$$T_a = t_\ell - t_1 \tag{13}$$

where t_ℓ is the analysis time corresponding to the last ESW examined. The result is the percent time p which the system spent in each condition.

$$p_i = \frac{100D_i}{T_a} \tag{14}$$

The number T_a is printed out. Also the p_i are printed out, along with the corresponding values of i, for i = 0, 1, 2, ---, N.

To illustrate, the above equations are applied to the first half of Table I (through t_9), again using the previously assumed values for the GMT's. T_{ik} and D_i are zero except for i = 0, 1, 2, and 3, and the expressions for these four cases are given in Table II.

T_{01} = 00/20' 03.200 (or 1,203 seconds)

T_{02} = 04/51' 35.019 (or 17,495 seconds)

T_{11} = 00/00' 53.095 (or 53 seconds)

T_{12} = 00/00' 30.842 (or 31 seconds)

T_{13} = 00/00' 24.656 (or 25 seconds)

T_{21} = 00/01' 18.356 (or 78 seconds)

T_{22} = 00/01' 09.321 (or 69 seconds)

T_{31} = 00/01' 20.167 (or 80 seconds)

Equation (11) then yields

$$D_0 = 1{,}203 + 17{,}495 = 18{,}698 \text{ seconds}$$

$$D_1 = 53 + 31 + 25 = 109 \text{ seconds}$$

$$D_2 = 78 + 69 = 147 \text{ seconds}$$

$$D_3 = 80 \text{ seconds}$$

Equation (13) yields

$$T_a = GMT_9 - GMT_1 = t_9 - t_1 = 05/17'\ 14.656 \quad \text{(or 19,035 seconds)}$$

Equation (14) yields

$$p_0 = \frac{(100)(18{,}698)}{19{,}035} = 98.2\%$$

$$p_1 = \frac{(100)(109)}{19{,}035} = 0.6\%$$

$$p_2 = \frac{(100)(147)}{19{,}035} = 0.8\%$$

$$p_3 = \frac{(100)(80)}{19{,}035} = 0.4\%$$

$$p_i = 0 \text{ for } i = 4, 5, \text{---} N$$

6. <u>Special Assumptions</u>

When the first ESW at t_1 is examined, no previous ESW's will be available for comparison. This is no problem if a NO CHAN OUT occurs at t_1. If, however, a channel or channels are indicated as being out, the assumption is made that these channels went OUT for the first time at t_1, even though previous ESW's, if available, might indicate otherwise. This amounts to assuming that the ESW preceding t_1 was a NO CHAN OUT.

When the last ESW at t_ℓ is examined, it may not provide conclusive information as to whether a status change occurred (for one or more channels). For example, if the last two ESW's are:

$t_{\ell-1}$ CHAN OUT 3 5

t_ℓ CHAN OUT 3 7

all one knows at t_ℓ is that channel 3 is still OUT, channel 5 went IN, and channel 7 went OUT. One does not know when either 3 or 7 will go IN. Hence one assumes that <u>channel 3 went IN</u> at t_ℓ, and ignores channel 7 since its outage does not fall within the time period analyzed T_a. Thus only that part of the channel 3 outage which falls within T_a is taken into account.

7. <u>Suggested Report Format</u>

The report for this analysis (DRAP Module 2) consists of two parts: header information (supplied before a run)* and summary data (calculated during the run).

7.1 <u>Header Information</u>

DATA RETRIEVAL AND ANALYSIS PROGRAM (DRAP)

DRAP MODULE 2 REPORT - D/TV OUTAGE ANALYSIS

MISSION ______________ N: __________ D/TV CHANNELS

(additional header information to be supplied for each mission, generally having the following format)

	GMT MISSION TIME	ANALYSIS TIME
START OF PRE-LAUNCH 1		
START OF AGENA LAUNCH		
START OF PRE-LAUNCH 2		
START OF GEMINI LAUNCH		
START OF ORBITAL		
START OF RE-ENTRY		
SPLASH DOWN		

(Note the above example events are peculiar to some of the GEMINI missions; the AS 204 mission will list different ones)

* The analysis times are not supplied, but must be calculated.

7.2 Summary Data Format

OUTAGE STATISTICS

CHAN NO.	OUTAGE DURATIONS (ordered in increasing value left to right)
1	____ ____ ____ ____ ____ ____
2	____ ____
3	
.	
.	
.	
i	____ ____ ____ ____
.	
.	
.	
N	____ ____ ____ ____ ____ ____ ____ ____ ____ ____

CHAN NO.	TOTAL OUTAGE TIME	NO. OUTAGES
1	S_1	n_1
2	S_2	n_2
.	.	.
.	.	.
i	S_i	n_i
.	.	.
.	.	.
N	S_N	n_N

TOTAL SYSTEM OUTAGE TIME: S_T

TOTAL SYSTEM NO. OUTAGES: n_T

AVAILABILITY STATISTICS

CONDITION	PERCENT TIME IN CONDITION
0	p_0
1	p_1
2	p_2
.	.
.	.
i	p_i
.	.
.	.
N	p_N

TOTAL ANALYSIS TIME: T_a

	GMT	ANALYSIS TIME
START OF ANALYSIS	GMT_1	t_1
END OF ANALYSIS	GMT_ℓ	t_ℓ

SECTION IV

ALGORITHM FOR CONSOLE ACTIVITY ANALYSIS

1. Required DRIP Input

The DRIP Report 1 (for all consoles) will provide a history of all operator requests and operator actions occurring between some Initial Time and some Final Time. ESW's, while not "operator actions", are to be included. Each action/request is identified by a time of occurrence (actually, time of input to the RTCC) in GMT notation, as well as by type of action (DRK, MSK, ESO, ESW, etc.). Other information, such as requesting console number, monitor, etc., is not needed for this analysis, although it may be for others (this analysis is one of four requiring an all-console Report 1). Although this analysis (and some others) require the data to be calculated for a number of contiguous time intervals, it may not be desirable to make this division into time frames at the time of running DRIP, since there is no "standard" time interval which will serve for all analyses or all missions. It will be assumed that DRAP does the division into specified time intervals.

2. Operation of DRAP Routines

DRAP routines operate on the DRIP Report 1 data (console actions and requests) to produce two types of summary data: Operator Actions Summary Data and Interarrival Time Summary Data. The former is essentially a tabulation, by time interval and by type, of the number of console actions; the latter is essentially that data (calculated without regard to time interval) necessary to plot histograms and cumulative distributions of interarrival time. Interarrival time is defined as the time between arrival of an action/request and arrival of the next action/request.

Some of the operations which must be performed by DRAP are:

(1) Calculate end-points of the time intervals and of the histogram ranges.

(2) Examine each action/request and classify it by type and time interval.

(3) Calculate various totals and subtotals, both within each interval and over all intervals, of the number of actions of various types.

(4) Compare the times-of-occurrence of actions (in pairs), to obtain the interarrival times, and calculate points for the associated histogram and cumulative distribution.

(5) Print out, in a suitable report format, the summary data and certain header information.

One way of accomplishing (3) above would be to set up a counter for each of the eight classes of action, and to increment the appropriate counter each time an action is examined. At the end of each time interval, the contents of various counters would be used for calculating certain subtotals, and then saved for later use.

3. Set-Up Calculations and Notation

Input parameters, set-up calculations, and notation are specified below for both types of summary data calculation.

3.1 Input Parameters

The input parameters which must be specified for each DRAP run are:

(1) GMT_s, the mission time at which the analysis is to start.

(2) GMT_f, the mission time beyond which no DRIP data is used in the analysis. Most, but not necessarily all, actions between GMT_s and GMT_f are used in the analysis.

(3) T, the duration in seconds of each time interval (same for all intervals). T may vary from 60 to 24,000 seconds.

(4) R, the length in seconds of each histogram range (same for all ranges). R may vary from 0.1 to 100 seconds.

GMT_s and GMT_f, while they must be specified to DRAP, can also be used as initial and final times for the DRIP run.

3.2 Set-Up and Notation

The set-up calculations required are similar to those in Sections 3.1.2 and 3.2.2 of the algorithm for DRAP Analysis Module No. 1 (RED/AMBER Analysis). However, a slightly different notation will be used here.

In Figure 1 is shown a hypothetical sequence of actions, as they might fall within the N time intervals (each of length T seconds). The τ's are times which mark the end-points of the time intervals T_1, T_2, ---, T_N. Note that i = 0, 1, ---, N for τ_i, but i = 1, 2, ---, N for the T_i. The units chosen for the τ_i are immaterial as far as internal calculations are concerned, but they must be accurate to thousandths of a second; as far as the report is concerned, the τ_i must be printed out in standard GMT notation.

The t_j are times-of-occurrence of actions, in any convenient notation (they do not have to be printed out but they must be accurate to thousandths of a second). For example, the figure shows an ESO action

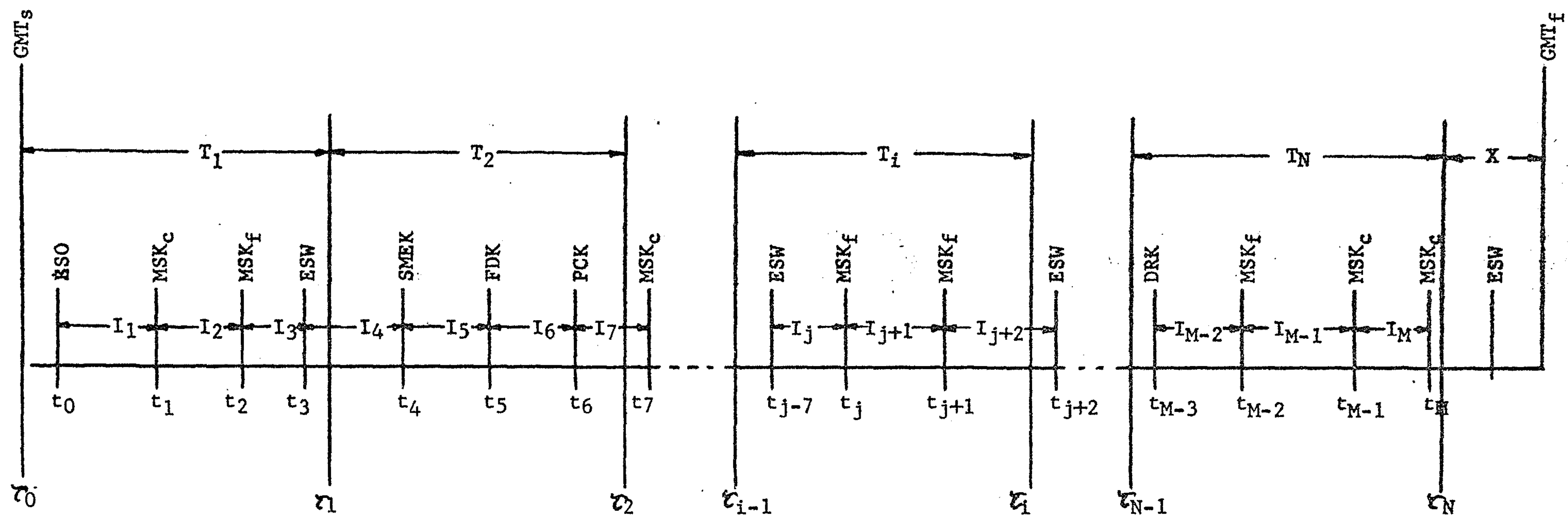

GMTs
GMTf
T1
T2
Ti
TN
X
ESO
MSKc
MSKf
ESW
SMEK
FDK
PCK
DRK
I1
I2
I3
I4
I5
I6
I7
Ij
Ij+1
Ij+2
IM-2
IM-1
IM
t0
t1
t2
t3
t4
t5
t6
t7
tj-7
tj
tj+1
tj+2
tM-3
tM-2
tM-1
tM
τ0
τ1
τ2
τi-1
τi
τN-1
τN

Figure 1

occurring at t_0, an MSK channel request action at t_1, an MSK format request action at t_2, etc. These times have to be subtracted in pairs to yield the interarrival times I_1, I_2, ---, I_M. Note that $j = 0, 1, ---, M$ for the t_j, but $j = 1, 2, ---, M$ for the I_j.

τ_0 (or GMT_s) is the start of the first interval. Calculate the end of this interval (and the start of T_2) by

$$\tau_1 = \tau_0 + T \tag{1}$$

Likewise,

$$\tau_2 = \tau_1 + T = \tau_0 + 2T \tag{2}$$

$$\tau_i = \tau_{i-1} + T = \tau_0 + (i)(T) \tag{3}$$

Continue, until a $\tau_i \geqq GMT_f$ results; the value of i when this happens is N + 1, where N is the number of intervals (N is to be printed out, as well as the τ_i). An alternate way of calculating N would be to calculate

$$\frac{GMT_f - GMT_s}{T} \tag{4}$$

If this is an integer, that integer is N, if not, set N equal to the next lower integer. Note that when (4) does not yield an integer, the last time interval T_N does not extend to GMT_f (see Figure 1); in this case there will be actions during some time (X in the figure) which are not used in the analysis. This will be the usual case.

The quantity M is the number of interarrival times (one less than the number of t's). At the end of the analysis, a number of these interarrival times (I's) will have been accumulated (on the order of 30 per minute of mission time analyzed, based on GT-8 experience).

A three-day mission could thus result in 130,000 or more I's. The largest I will be called I_{max}.

The I's are allocated to n histogram ranges, R_1, R_2, R_3, ---, R_q, ---, R_n, where the end points of the ranges are found as follows:

(1) The first range R_1 begins at 0, and extends to $r_1 = R$ seconds.

(2) The second range R_2 begins at r_1 and extends to $r_2 = r_1 + R = 2R$ seconds.

(3) Continue calculating end-points r_q where $r_q = r_{q-1} + R = (q)(R)$ seconds, until the last end-point r_n has been calculated. The r_q are in seconds and must be accurate to thousandths of a second, for comparison with the I_j.

The number of ranges n is found by calculating

$$\frac{I_{max}}{R} \tag{5}$$

If this is an integer, that integer is n, if not, n is the next higher integer (n is printed out, as is I_{max} and the set of r_q).

4. Calculation of Summary Data

Using the results of Section 3.0, DRAP will calculate Operator Actions Summary Data and Interarrival Time Summary Data.

4.1 Operator Actions Summary Data

The actions are classified into the following eight classes.

Class 1. This includes all FDK actions. The number of these in the i^{th} time interval is m_{i1}.

Class 2. This includes all PCK actions. The number of these in the i^{th} interval is m_{i2}.

Class 3. This includes all ESO actions. The number of these in the i^{th} interval is m_{i3}.

Class 4. This includes all SMEK actions. The number of these in the i^{th} interval is m_{i4}.

Class 5. This includes all ESW actions. The number of these in the i^{th} interval is m_{i5}.

Class 6. This includes all DRK actions. The number of these in the i^{th} interval is m_{i6}.

Class 7. This includes all MSK actions <u>of the format request type</u>, i.e., MSK_f's. The number of these in the i^{th} interval is m_{i7}.

Class 8. This includes all MSK actions <u>of the TV channel request type</u>, i.e., MSK_c's. The number of these in the i^{th} interval is m_{i8}.

The number of actions of each class is counted for each interval (a t_j belongs to T_i if $\tau_{i-1} < t_j \leq \tau_i$). This results in a set of 8N numbers, i.e., m_{i1}, m_{i2}, ---, m_{i8} each for i = 1, 2, ---, N. These are printed out in a matrix form having columns corresponding to classes and rows corresponding to values of i. Also included in the matrix are the numbers m_{i9}, m_{i10}, and m_{i11}, where

$$m_{i9} = m_{i7} + m_{i8} \quad \text{(total MSK actions)} \tag{6}$$

$$m_{i10} = m_{i6} + m_{i7} \quad \text{(total format requests)} \tag{7}$$

$$m_{i11} = m_{i1} + m_{i2} + 2m_{i3} + 2m_{i4} + m_{i5} + m_{i6} + m_{i9} \quad \text{(total CIM words)} \tag{8}$$

Also included in the matrix is

$$m_{i12} = m_{i1} + m_{i2} + m_{i3} + m_{i4} + m_{i6} + m_{i9} \quad \text{(number of pushbutton actions)} \tag{9}$$

$$m_{i13} = m_{i12} + m_{i5} \quad \text{(total number of actions)} \tag{10}$$

When all matrix elements have been calculated (based on GT-8, the element values could range from 0 to 22,000 or higher), each column is summed to obtain totals:

$$\begin{aligned} S_1 &= \sum_{i=1}^{N} m_{i1} \\ S_2 &= \sum_{i=1}^{N} m_{i2} \\ &\vdots \\ S_{13} &= \sum_{i=1}^{N} m_{i13} = M \end{aligned} \tag{11}$$

Also calculated is

$$S_{14} = S_1 + S_2 + S_3 + S_4 \tag{12}$$

and certain totals expressed as percentages of S_{12}:

$$P_{14} = \frac{100S_{14}}{S_{12}} \tag{13}$$

$$P_6 = \frac{100S_6}{S_{12}} \tag{14}$$

$$P_7 = \frac{100S_7}{S_{12}} \tag{15}$$

$$P_8 = \frac{100S_8}{S_{12}} \tag{16}$$

$$P_9 = \frac{100S_9}{S_{12}} \tag{17}$$

$$P_{10} = \frac{100S_{10}}{S_{12}} \tag{18}$$

All of the above totals and percentages are printed out. The largest total is S_{11}; based on GT-8, this could be as large as 130,000 or more for a three-day mission.

4.2 Interarrival Time Summary Data

The individual times-of-occurrence of actions are subtracted in pairs to obtain interarrival times.

$$I_1 = t_1 - t_0 \tag{19}$$

$$I_2 = t_2 - t_1 \tag{20}$$

$$\vdots$$

$$I_j = t_j - t_{j-1} \tag{21}$$

$$\vdots$$

$$I_M = t_M - t_{M-1} \tag{22}$$

The resulting set of I's is allocated to the various histogram ranges, R_q, a given I being allocated

$$\text{to } R_1, \text{ if } 0 < I \leq r_1 \quad , \tag{23}$$

$$\text{to } R_2, \text{ if } r_1 < I \leq r_2 \quad , \tag{24}$$

$$\text{to } R_3, \text{ if } r_2 < I \leq r_3 \quad , \tag{25}$$

$$\vdots$$

$$\text{to } R_q, \text{ if } r_{q-1} < I \leq r_q \quad , \tag{26}$$

etc. The number of I's in each range is counted to yield a set of c_q, $q=1, 2, ---, n$. These are printed out, along with the corresponding values of q and r_q. Also calculated and printed out are a set of p_q, where

$$p_q = \frac{100c_q}{M} \tag{27}$$

The value of the p_q will range from 0 to 100, and should be accurate to two decimal places (i.e., to five digits).

Also calculated and printed out is the sum S_I of all the I's

$$S_I = \sum_{j=1}^{M} I_j = t_M - t_0 \tag{28}$$

in any convenient units, the mean interarrival time

$$\bar{I} = \frac{S_I}{M} \tag{29}$$

in seconds,

and the reciprocal of this,

$$\bar{R} = \frac{1}{\bar{I}} \tag{30}$$

In order to obtain points for a cumulative distribution of interarrival times, the quantities

$$F_k = \sum_{q=1}^{k} p_q \; , \; k = 1, 2, ---, n \tag{31}$$

are computed and printed out, along with corresponding values of k.

5. Report Format

As for DRAP modules 1 and 2, the report consists of two parts: header information (the variable part of this is supplied for each run) and summary data (mostly the result of calculations).

5.1 Header Information

DATA RETRIEVAL AND ANALYSIS PROGRAM (DRAP)

DRAP MODULE 3 REPORT - CONSOLE ACTIVITY ANALYSIS

MISSION ______________ GMT_s ______________ GMT_f __________

NUMBER OF CONSOLES ____________________

(Additional header information to be supplied for each mission, generally having the following format)

	GMT MISSION TIME
START OF PRE-LAUNCH 1	____________
START OF AGENA LAUNCH	____________
START OF PRE-LAUNCH 2	____________
START OF GEMINI LAUNCH	____________
START OF ORBITAL	____________
START OF RE-ENTRY	____________
____________	____________
____________	____________
____________	____________
____________	____________
____________	____________
____________	____________

5.2 Summary Data

T - ________________ seconds N - ____________ intervals

i	τ_i (GMT)
0	τ_0 (=GMT_s)
1	τ_1
2	τ_2
⋮	⋮
i	τ_i
⋮	⋮
N	τ_N

(included here, if there is room on the print-out, is the matrix of console actions shown on the next page; this matrix has entries for all values of i <u>except 0</u>. If not room in this position, print directly below.)

M - ______(S13)______ actions S_{12} - ____________ PB actions

R - ________________ seconds n - _________ranges I_{max} - _____ sec.

q	r_q	c_q	p_q
1	r_1	c_1	p_1
2	r_2	c_2	p_2
3	r_3	c_3	p_3
⋮	⋮	⋮	⋮
n	r_n	c_n	p_n

k	F_k
1	F_1
2	F_2
3	F_3
⋮	⋮
n	F_n

i (interval)	FDK	PCK	ESO	SMEK	ESW	DRK	MSK_f	MSK_c	MSK (total)	FORMAT REQUESTS (total)	CIM WORDS	NUMBER OF ACTIONS (no ESW)	NUMBER OF ACTIONS (with ESW)
1	m11	m12	m13	m14	m15	m16	m17	m18	m19	m110	m111	m112	m113
2	m21	m22	m23	m24	m25	m26	m27	m28	m29	m210	m211	m212	m213
3	m31	m32	m33	m34	m35	m36	m37	m38	m39	m310	m311	m312	m313
i	$m_{i}1$	$m_{i}2$	$m_{i}3$	$m_{i}4$	$m_{i}5$	$m_{i}6$	$m_{i}7$	$m_{i}8$	$m_{i}9$	$m_{i}10$	$m_{i}11$	$m_{i}12$	$m_{i}13$
N	$m_{N}1$	$m_{N}2$	$m_{N}3$	$m_{N}4$	$m_{N}5$	$m_{N}6$	$m_{N}7$	$m_{N}8$	$m_{N}9$	$m_{N}10$	$m_{N}11$	$m_{N}12$	$m_{N}13$
TOTALS	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}	S_{13}
PERCENT			P_{14}			P_6	P_7	P_8	P_9	P_{10}			

S_I - ________________ $\overline{I}$ - _____________ seconds

$\overline{R}$ - _________________

SECTION V

ALGORITHM FOR DISPLAY REQUEST PROCESSING DELAY

1. Required DRIP Input

DRIP Report 1 will provide times-of-occurrence of DRK and MSK actions for all consoles. The actions of interest here are display format requests and TV channel requests. These requests constitute a large part (about 98%, based on GT-8 experience) of all actions listed by Report 1.

DRIP Report 3 (abbreviated form, all consoles) will provide times-of-output of all Channel and Slide Words (C/S words) and all Command Words. The C/S words are sufficient to describe the RTCC responses to the requests above.

A suitable merger of Reports 1 and 3 allows a given request to be correlated with the corresponding response. The difference between their times of occurrence is the RTCC processing delay. The merged Reports 1 and 3 will provide times of all requests and responses between some initial time GMT_s and some final time GMT_f. These times also define the time span covered by the analysis. Time, per se, is not of fundamental interest in the analysis since no time histories are produced; only time differences (or delays) are of real interest.

2. Operation of DRAP Routines

DRAP must perform at least the following functions:

(1) Examine DRK and MSK requests, and categorize these into two classes: format requests, and TV channel requests.

(2) Examine responses (C/S words or "74" words) and categorize them into two classes: display initiation responses, and latch-only responses.

(3) Match requests to responses to form request/response pairs.

(4) Resolve certain anomalies such as incomplete pairs (a request with no response, or vice versa).

(5) For each request/response pair, subtract request time from response time to obtain delay and classify these delays into three sets, depending on class of request and response.

(6) Determine for each set, the sum of the delays and the maximum delay.

(7) Count the total number of delays in each set (total number of delays used in each of three histograms), and add these to get grand total number of delays.

(8) Allocate the delays in each set to histogram intervals, and count the number in each interval; the result, after further calculation, is data for plotting three histograms.

(9) Calculate the mean delay for each set (for each histogram) and for all sets (total average delay).

(10) Print out certain header information plus summary data resulting from the above calculations.

3. Input Parameters

Input parameters which must be specified to DRAP are:

a. GMT_s, the mission time at which the analysis starts. GMT_s can be used for DRIP initial time.

b. GMT_f, a mission time beyond which no request/response data is used. GMT_f can be used for DRIP final time.

c. R, the length in seconds of each histogram range (same for all ranges). R may vary from 0.001 to 10.0 seconds.

4. Set-Up Calculations

The set-up calculations required for the histogram ranges (same for each histogram) are similar to those in Section 3.2.2 of DRAP Analysis Module No. 1 (RED/AMBER Analysis), except that the word "duration" is replaced by "delay."

5. Notation, Definitions, and Anomalies

The items of Section 2 are discussed below in more detail; the numbers correspond to those of Section 2.

(1) Format requests can arise from either MSK's or DRK's. Their times of occurrence will be denoted by t_f. Channel requests can arise from MSK's only; their times of occurrence are denoted by t_c. Note that reference slide requests and mark commands are not of interest.

(2) Display initiation responses (occurring at times t_D) may be of two types. The first type is a 74 word which produces a single line of DRIP printout, specifying channel, console, monitor, and converter slide number; the time of this word is taken to be t_D. The second type consists of two sequential words; these produce two lines of DRIP printout. The first specifies latch information only and the second specifies converter slide number (a false "console number" and other information is specified in this second line). The time of the second word (containing the converter slide number) is taken to be t_D.

Latch-only responses (no converter slide number given) occur at times t_ℓ and may be of two types: a type which produces a line of DRIP listing containing the words, "FOR CONVERTER SLIDE NONE"; and a type which does not produce these words. The first type results from a latch involving a converter channel (Channels 1 - 32) while the second type results from a latch involving a non-converter channel. Both types provide channel number, console, and monitor information; regardless of type, the time of occurrence is taken to be t_ℓ. Note that no Command Words ("76 words") are examined; neither are 74 words which specify reference slides. Also ignored, as far as t_ℓ is concerned, is any first word of a pair which constitutes one type of display initiation response as discussed in the preceding paragraph.

(3) A given request is presumably matched with the next (in time sequence) response having the same console and monitor destination.

(4) Incomplete pairs may occur quite normally as a result of certain operator actions (requesting an "illegal" format number, or generating multiple requests by holding the "enter" button down), or as a result of certain system conditions (when no TV channels are available, a display request may cause no response). They may also occur at the beginning or end of the analysis, due to truncation of data. The number M_i of incomplete pairs is to be determined and printed out.

(5) The table below shows how each type of delay is defined. Note that the delay type can be determined only by examining both request and response class.

CLASS AND TIME OF REQUEST	CLASS AND TIME OF RESPONSE	TYPE OF DELAY
MSK Channel Request at t_c	Latch-only Response at t_ℓ	$\tau_1 = t_\ell - t_c$
MSK or DRK Format Request at t_f	Latch-only Response at t_ℓ	$\tau_2 = t_\ell - t_f$
MSK or DRK Format Request at t_f	Display Initiation Response at t_D	$\tau_3 = t_D - t_f$

(6) For each type of delay, denote the sum of all delays of that type as follows:

$$S_1 = \Sigma \tau_1 \tag{1}$$

$$S_2 = \Sigma \tau_2 \tag{2}$$

$$S_3 = \Sigma \tau_3 \tag{3}$$

Also, denote $S = S_1 + S_2 + S_3$.

Also, denote the maximum delay of each type by τ_{1max}, τ_{2max}, and τ_{3max}; select the greatest of these and call it τ_{max}. Use τ_{max} to calculate the number n of histogram ranges, as in Section 3.2.2 (2) of the RED/AMBER Analysis. All histograms, in theory, will have the same number of ranges (but see (8)).

(7) Let the number of delays in each of the three sets be M_1, M_2, and M_3. Calculate $M = M_1 + M_2 + M_3$.

(8) Let c_j be the number of delays allocated to the R_j range of a histogram, where a delay is allocated to R_j if

$$r_{j-1} < \tau \leq r_j, \tag{4}$$

and let p_j be defined by

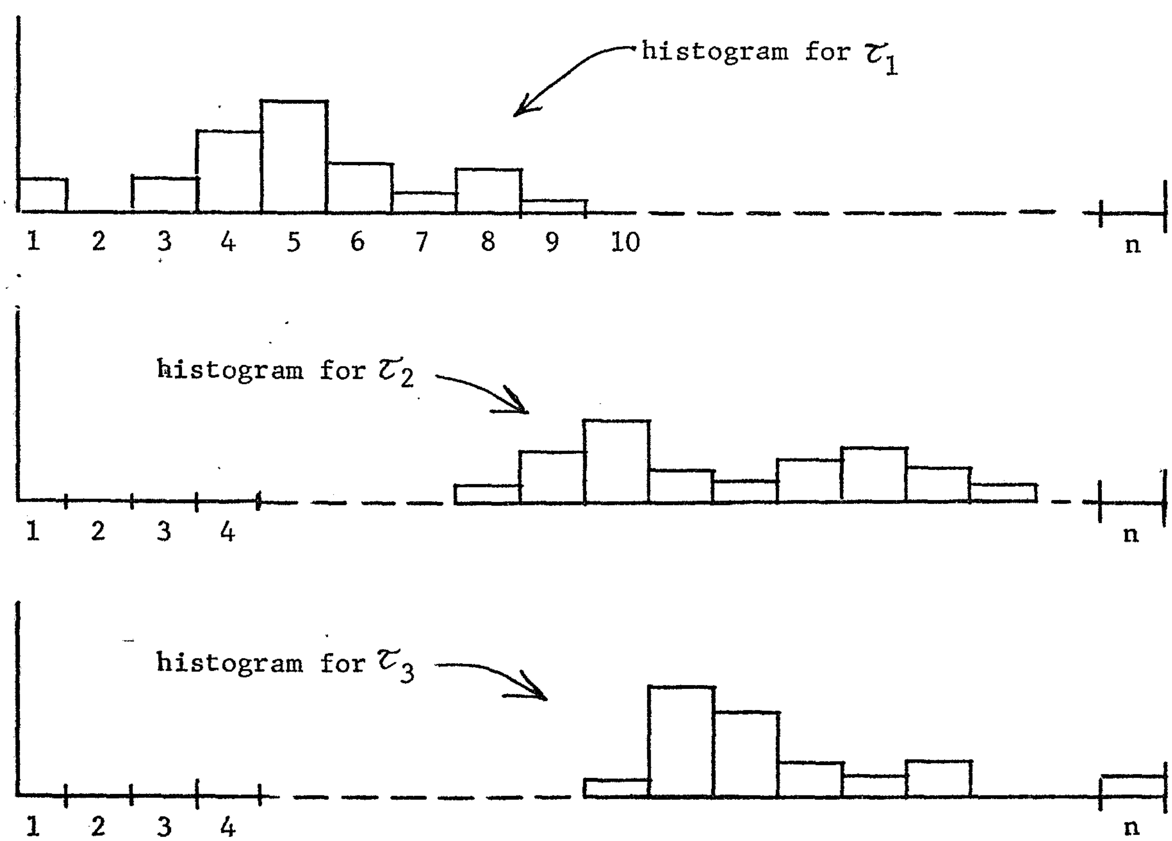
$$p_{1j} = \frac{100c_{1j}}{M_1} \tag{5}$$

$$p_{2j} = \frac{100c_{2j}}{M_2} \tag{6}$$

$$p_{3j} = \frac{100c_{3j}}{M_3} \tag{7}$$

The c_j and p_j are printed out, along with j and r_j. Also printed out are the M's and the τ_{max}'s.

Each of the three histograms will use the same number of ranges n, but due to differences in the nature of the histograms, many of the ranges may be "empty" (no τ's allocated to them), as shown in the hypothetical example below.



The c_j and p_j need not be printed out for ranges where they are zero (e.g., for range 2 and ranges 10,11,---, n on the τ_1 histogram).

(9) Also printed out are mean values

$$\bar{\tau}_1 = \frac{S_1}{M_1} \qquad (8)$$

$$\bar{\tau}_2 = \frac{S_2}{M_2} \qquad (9)$$

$$\bar{\tau}_3 = \frac{S_3}{M_3} \qquad (10)$$

$$\bar{\tau} = \frac{S}{M} \qquad (11)$$

(10) A suggested report format is shown in the next section. Note that the time span covered by the analysis, $GMT_f - GMT_s$, is calculated and printed out.

6. Suggested Report Format

Certain supplied data are printed out as header information, followed by input and summary data.

6.1 Header Information

DATA RETRIEVAL AND ANALYSIS PROGRAM (DRAP)

DRAP MODULE 4 REPORT - DISPLAY REQUEST PROCESSING DELAY ANALYSIS

MISSION ____________ GMT_s ____________ GMT_f ____________

NUMBER OF DISPLAY REQUEST DEVICES ____________

6.2 Summary Data Format

TOTAL NUMBER OF DELAYS M ____________________

NUMBER OF INCOMPLETE PAIRS M_i ____________________

ANALYSIS TIME ___(GMT$_f$ - GMT$_s$)___________

HISTOGRAM RANGE R ________________ SECONDS

τ_{1max} -	______________	seconds	M_1 -	______________	delays
τ_{2max} -	______________	seconds	M_2 -	______________	delays
τ_{3max} -	______________	seconds	M_3 -	______________	delays
$\bar{\tau}_1$ -	______________	seconds	S_1 -	______________	seconds
$\bar{\tau}_2$ -	______________	seconds	S_2 -	______________	seconds
$\bar{\tau}_3$ -	______________	seconds	S_3 -	______________	seconds
$\bar{\tau}$ -	______________	seconds	S -	______________	seconds

j	r_j	c_{1j}	p_{1j}	c_{2j}	p_{2j}	c_{3j}	p_{3j}
1	r_1	c_{11}	p_{11}	c_{21}	p_{21}	c_{31}	p_{31}
2	r_2	c_{12}	p_{12}	c_{22}	p_{22}	c_{32}	p_{32}
3	r_3	c_{13}	p_{13}	c_{23}	p_{23}	c_{33}	p_{33}
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
n	r_n	c_{1n}	p_{1n}	c_{2n}	p_{2n}	c_{3n}	p_{3n}

SECTION VI

ALGORITHM FOR DISPLAY CHANNEL UTILIZATION

1. Required DRIP Input

The DRIP Report 3 (abbreviated, all consoles) yields the channel latch information (74_8 words) necessary to construct a time history of the number of console monitors or group displays simultaneously latched to each of the VSM input channels.

This information also exists internal to DRIP, in the form of a "channel/console matrix" which is updated as changes occur in the status of channel latches. The information in this matrix is in a more desirable form than that normally printed out for Report 3; it is also more inaccessible.

Thus if the standard DRIP report is used as input to DRAP, then DRAP must reconstruct the matrix. The other alternative is to modify DRIP such that the matrix and its updates are written out on a DRIP print tape for direct input to DRAP without further matrix calculations. Whichever alternative is used, it will be assumed that the matrix and its updates are available to DRAP, and DRAP operation will be described with this assumption as a starting point.

The starting times (GMT mission times) used for DRIP and DRAP are not independent, and depend on the choice of above alternatives (see the discussion of Section 6 on transient effects).

2. Operation of DRAP Routines

DRAP operates on the channel/console matrix data to produce three types of summary data:

A. Latch - Distribution Summary Data

B. Channel - Usage Summary Data

C. System - Usage Summary Data

The first type of summary data is concerned with the time-variation in the number of latches on individual channels, time averages of this quantity, a summation (over channels) of the time averages, and an average (over groups of channels) of the time averages.

The second type of summary data is concerned with the time variation in the condition (in-use or not-in-use) of individual channels, the percent of total analysis time represented by the total duration of the "in use" condition, and the average (over groups of channels) of this percentage.

The third type of summary data is concerned with the time variations and durations of the state of the D/TV channels, where all N_1 channels are considered as a single system. At present, $N_1 = 28$, and hence there are 29 system states: 0 channels in use, 1 channel in use, 2 channels in use, ---, 28 channels in use. Of interest are the total duration of each state, this quantity expressed as a percentage of total analysis time, and the mean value of the system state.

DRAP must do at least the following things:

(1) For each channel (not just D/TV channels), examine matrix elements, row by row, every time any changes occur in the elements. Associate the time of the element changes with resulting changes in a quantity (number of latches) computed for each row (i.e., for each channel).

(2) Calculate the durations of each value taken on by the number of latches, separately for each channel.

(3) Quantize the number of latches from (1) into two levels (= 0, >0) and calculate the durations of one of these channel conditions (>0), separately for each channel.

(4) Examine, simultaneously, for all of a subset of the channels (i.e., for the D/TV channels), the channel conditions of (3), and determine the number of D/TV channels simultaneously in the "in-use" condition (described as " >0" in (3)). Call this number the "system state." Make this examination every time a change occurs in matrix elements, but record only those times at which a change occurs in the system state.

(5) Calculate the durations of the various system states.

(6) During the analysis times, accumulate, from (2), the durations of each value and sum these separately for each value and each channel. Also accumulate the durations of (3), and sum these separately for each channel. Also, accumulate the durations of (5), and sum the durations for each value of system state.

(7) Calculate total analysis time.

(8) Calculate certain further sums, percentages, and averages, using the results of (6) and (7) together with input parameters. These additional quantities are defined in Section 5.

(9) Print out certain header information, as well as specified parameters and summary data.

3. Input Parameters

The input parameters which must be specified to DRAP are:

(1) GMT_s, the mission time at which the analysis starts. This may not be the same as either DRIP or DRAP initial times.

(2) GMT_f, the mission time at which the analysis ends. This can be used as DRIP final time.

(3) N_1, the number of D/TV channels available for the mission being analyzed. There are presently 28 of these, but this number is subject to change in the future and hence N_1 should be a specified parameter in DRAP. If it is assumed that D/TV channels will always be numbered sequentially starting with 1, then there is no need to specify the numbers themselves.

(4) N_2, the number of non-D/TV channels which are assigned for the mission being analyzed (out of the total number of available non-D/TV channels, some are usually unassigned, i.e., "spares"). N_2 includes reference slide channels, opaque cameras, etc.

All of the input parameters are printed out.

4. Set-Up Calculations

This analysis produces no time histories or histograms, as such, and hence no set-up calculations are required in these areas.

5. Detailed Calculations

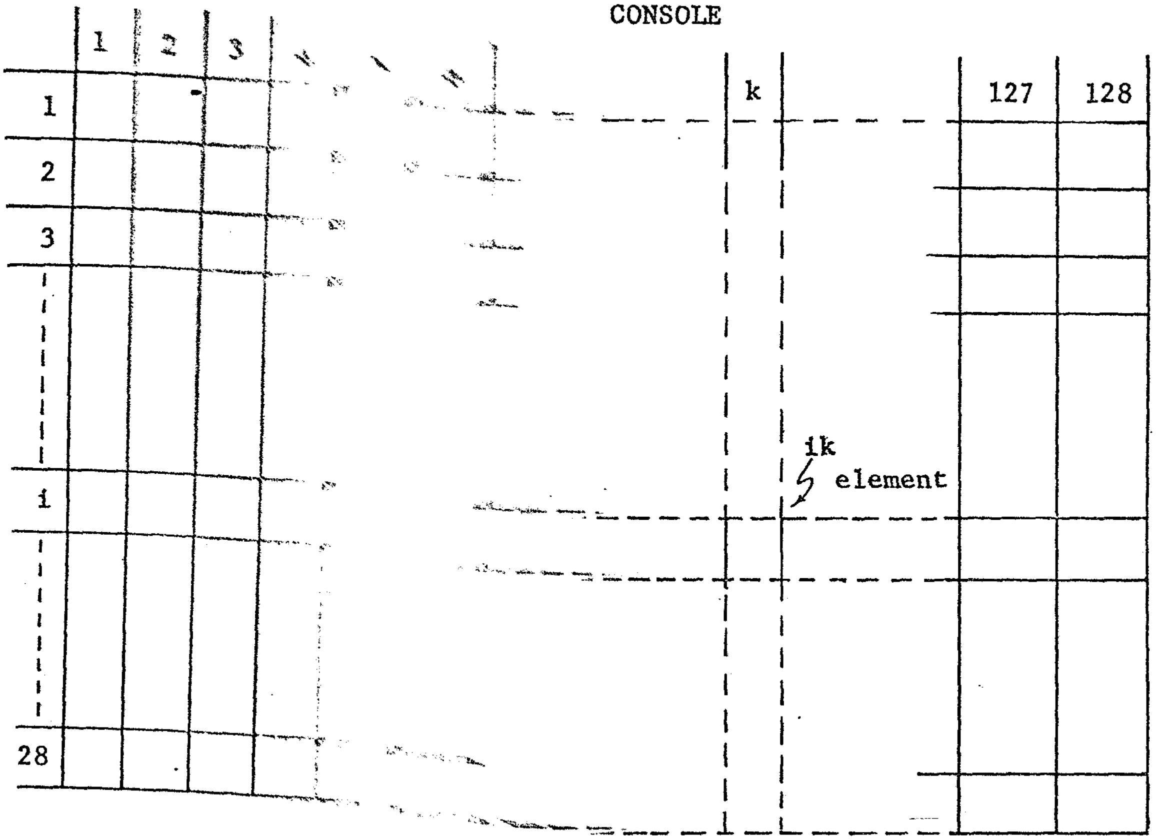
Many of the calculations are similar to those of DRAP Analysis Module No. 2 (D/TV Outage Analysis), except that the conditions of a channel are "in-use" and "not-in-use" instead of IN and OUT; also the system state refers to number of channels simultaneously in use whereas the system condition of Module 2 refers to number of channels simultaneously out of order. The detailed calculation of each of the three types of summary data is given below, each discussion being based on Figures 1 and 2 and on various parts of Table I.

5.1 Channel/Console Matrix

Figure 1 shows the organization of the channel/console matrix, as it exists internal to the DRIP program. The matrix has 128 rows, each row corresponding to a VSM input channel. As of GT-12, there were only 70 channels physically installed; the remaining 58 rows in the matrix represent expansion capability. Channels 1 through 28 (rows 1 through 28 in the matrix) correspond, at present, to the 28 D/TV channels. Of the remaining 42 channels, 11 were designated as "spares" for GT-12, leaving 31 assigned non-D/TV channels. Hence for GT-12, $N_1 = 28$ and $N_2 = 31$, but these numbers may be different for other missions.

The matrix has 128 columns, each column corresponding to a console. There were roughly half this many consoles installed in MOCR 1 (Room 330) for GT-12 (not counting consoles served exclusively by the Auxiliary Display System). The remaining columns represent expansion capability.

In each element of the matrix is kept an updated list of monitors, associated with the corresponding console, which are latched to the corresponding channel. Here, "monitor" is used in a broad sense and includes wall monitors and group display screens as well as console monitors. DRIP provides for up to eight monitor designations for each console. As the console operators make new display and channel requests, and these are translated into latches, the data in the matrix elements changes. These changes, on a time basis, always occur in simultaneous pairs, i.e., at the time of any change in an element, some other element in the same column experiences a corresponding change. For example, if console 5 had its left monitor latched to channel 12, and the operator requested channel 34 for his left monitor, the element for row 12, column 5 would



The ik element of the matrix contains the designations of those monitors (controlled from the kth console) which are latched to the i^{th} channel. The maximum number of monitors controllable from one console is eight.

CHANNEL/CONSOLE MATRIX

FIGURE 1

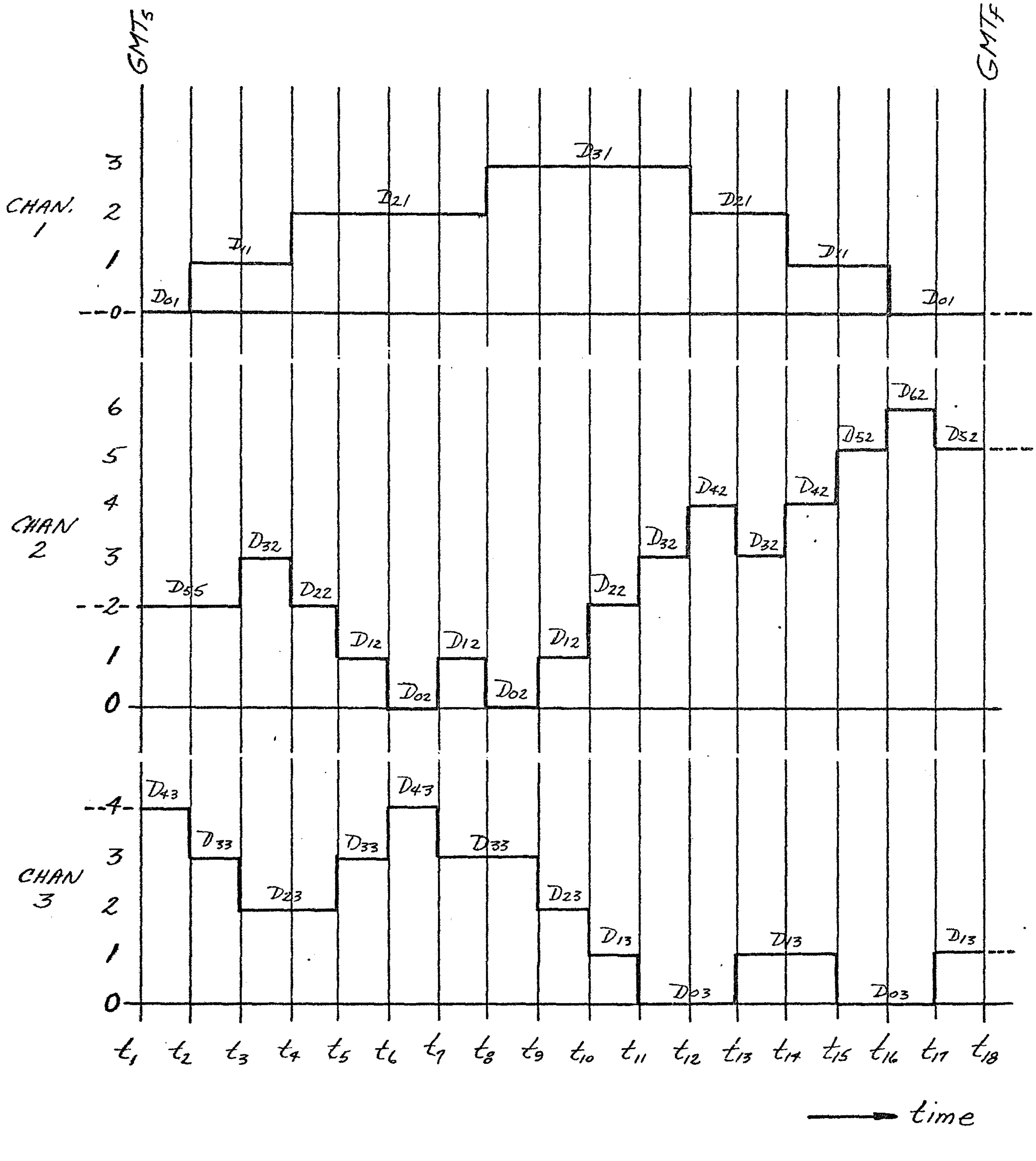
have "left monitor" deleted; simultaneously, "left monitor" would be added to the contents of the element at row 34, column 5.

5.2 Notation and Calculations

In Figure 2 is shown the hypothetical time variation of number of latches on each of three channels. The number of latches on each channel is plotted vertically, and time is plotted horizontally, with the t's representing times-of-occurrence of latch changes. GMT_s, the start of the analysis, is identical to t_1. For the particular example shown, GMT_f, the end of the analysis, occurs after the 16th change in latch-status, and hence is labeled t_{18}. It is assumed that a given monitor can be latched to only one channel at a time (the converse is not true).

The durations D_{ni} are also indicated, where D_{ni} is the duration of an n-latch condition on channel i; these durations are placed directly above the horizontal segment whose length they represent.

As can be seen, a change in number of latches on any one channel is always accompanied by a simultaneous change on one of the other two channels. For example, there are two monitors latched to channel 2 at GMT_s. At t_3, this increases to three latches, as a monitor is "de-latched" from channel 3 and latched to channel 2. In effect, the monitors are constantly being re-distributed over the channels by the actions of the operators. By the physical nature of the system, a monitor is always latched to one, and only one, channel, hence the total number of monitors latched to the system is constant. In the example, this number is 6, as can be verified by summing the number of latches vertically



HYPOTHETICAL LATCH HISTORY FOR THREE CHANNELS

FIGURE 2

TIME	CHANNEL 1				CHANNEL 2				CHANNEL 3				SYSTEM	
	LATCH COUNTER	LATCH DURATION	CHAN-COND. COUNTER	CONDITION DURATION	LATCH COUNTER	LATCH DURATION	CHAN-COND COUNTER	CONDITION DURATION	LATCH COUNTER	LATCH DURATION	CHAN-COND COUNTER	CONDITION DURATION	SYS.-STATE COUNTER	STATE DURATION
	n_1	D_{n1}	u_1	C_{u1}	n_2	D_{n2}	u_2	C_{u2}	n_3	D_{n3}	u_3	C_{u3}	j	D_j
t_1	0	$t_2 - t_1$	0	$t_2 - t_1$	2		1		4	$t_2 - t_1$	1		2	$t_2 - t_1$
t_2	1		1		2	$t_3 - t_1$	1		3	$t_3 - t_2$	1		3	
t_3	1	$t_4 - t_2$	1		3	$t_4 - t_3$	1		2		1		3	
t_4	2		1		2	$t_5 - t_4$	1		2	$t_5 - t_3$	1		3	
t_5	2		1		1	$t_6 - t_5$	1	$t_6 - t_1$	3	$t_6 - t_5$	1		3	$t_6 - t_2$
t_6	2		1		0	$t_7 - t_6$	0	$t_7 - t_6$	4	$t_7 - t_6$	1		2	$t_7 - t_6$
t_7	2	$t_8 - t_4$	1		1	$t_8 - t_7$	1	$t_8 - t_7$	3		1		3	$t_8 - t_7$
t_8	3		1		0	$t_9 - t_8$	0	$t_9 - t_8$	3	$t_9 - t_7$	1		2	$t_9 - t_8$
t_9	3		1		1	$t_{10} - t_9$	1		2	$t_{10} - t_9$	1		3	
t_{10}	3		1		2	$t_{11} - t_{10}$	1		1	$t_{11} - t_{10}$	1	$t_{11} - t_1$	3	$t_{11} - t_9$
t_{11}	3	$t_{12} - t_8$	1		3	$t_{12} - t_{11}$	1		0		0		2	
t_{12}	2		1		4	$t_{13} - t_{12}$	1		0	$t_{13} - t_{11}$	0	$t_{13} - t_{11}$	2	$t_{13} - t_{11}$
t_{13}	2	$t_{14} - t_{12}$	1		3	$t_{14} - t_{13}$	1		1		1		3	
t_{14}	1		1		4	$t_{15} - t_{14}$	1		1	$t_{15} - t_{13}$	1	$t_{15} - t_{13}$	3	$t_{15} - t_{13}$
t_{15}	1	$t_{16} - t_{14}$	1	$t_{16} - t_2$	5	$t_{16} - t_{15}$	1		0		0		2	$t_{16} - t_{15}$
t_{16}	0		0		6	$t_{17} - t_{16}$	1		0	$t_{17} - t_{15}$	0	$t_{17} - t_{15}$	1	$t_{17} - t_{16}$
t_{17}	0		0		5		1		1		1		2	
t_{18}	0	$t_{18} - t_{16}$	0	$t_{18} - t_{16}$	5	$t_{18} - t_{17}$	1	$t_{18} - t_9$	1	$t_{18} - t_{17}$	1	$t_{18} - t_{17}$	2	$t_{18} - t_{17}$

TABLE I

across channels at any given instant (except at times of changes). This is also evident between t_{16} and t_{17}, where all six monitors have been latched to channel 2, leaving none on the other channels. Note that "de-latches" are <u>inferred</u> by the analysis program; only positive "latch" information is contained in the C/S words. For example, prior to t_{12} there were three latches on channel 1. Suppose that one of these is for the right monitor of console 6 (this would be recorded in the 1 - 6 element of the matrix). At t_{12}, a C/S word is received, indicating a latch of this particular monitor to channel 2. Knowing that its previous latch was to channel 1, it can be inferred that a de-latch from channel 1 has occurred, as shown. At t_{12}, then, both the 1 - 6 element and the 2 - 6 element of the matrix will change. For the example of Figure 2, only the first three rows, and not more than the first six columns, of the matrix would have entries (if all six monitors were controlled by the same console, only the first column would have entries).

In Table I is tabulated some significant channel and system quantities. This table continues the example of Figure 2, and has entries corresponding to the changes of that example. In the first column are listed the various times of interest. These, and hence the durations calculated from them, must be accurate to at least one millisecond. Each of three major columns, representing three channels, are identical in format. In each, the first sub-column gives n_i, the number of latches to channel i (i = 1, 2, ---, 128 in the matrix, although there will be at most $N_1 + N_2$ matrix rows with entries). The value of n_i is the number of latches <u>immediately after</u> the corresponding time. The heading of this subcolumn implies that n_i is represented for each channel by the contents of a counter which is incremented by 1 whenever a new latch is added to channel i and is decremented by 1 whenever there is a de-latch from channel i.

The second subcolumn gives values of D_{ni} in terms of the t's. For example, there is a duration of the four-latch condition on channel 2 (i.e., a D_{42}) between t_{12} and t_{13}, hence this D_{42} has a value of $t_{13} - t_{12}$; there is another D_{42} for this channel between t_{14} and t_{15}.

The third subcolumn gives u_i, a quantized version of n_i, where $u_i = 0$ if $n_i = 0$ ("not-in-use" channel condition) and $u_i = 1$ if $n_i > 0$ ("in-use" channel condition). This subcolumn's heading implies that the condition of each channel is represented by the contents of a channel-condition counter which is incremented by 1 when n_i changes from 0 to 1 and is decremented by 1 when n_i changes from 1 to 0.

The fourth subcolumn gives the durations C_{ui} of the channel conditions, where i is channel number and u is condition (0 or 1). There is a C_{12} of $t_6 - t_1$, another C_{12} of $t_8 - t_7$, and a third C_{12} of $t_{18} - t_9$, for channel 2; this channel also has C_{02}'s of $t_7 - t_6$ and $t_9 - t_8$.

The last major column gives quantities pertaining to the system, where "system" means the set of N_1 D/TV channels. Here j, indicated as the contents of a "system counter", is the number of such channels simultaneously "in use", i.e., for which $u_i = 1$. Note $j = 0, 1, ---, N_1$. The D_j are durations of the j^{th} system state, given in terms of the t's.

Calculation of the three types of summary data is described below, using the above notation.

Latch-Distribution Summary Data

For each channel, sum each type of D_{ni} (i.e., sum the D_{0i}, the D_{1i}, the D_{2i}, etc.), to get S_{ni}, the total time during which there were n latches on the i^{th} channel.

$$S_{ni} = \sum D_{ni} \tag{1}$$

As a check, the sum $\sum_n S_{ni}$ should be equal to the analysis time T_a = GMT_f - GMT_s, for each channel.

Compute, for each channel, the weighted average (time-averaged number of latches on channel i).

$$\bar{n}_i = \frac{S_{1i} + 2S_{2i} + 3S_{3i} + \text{---} + nS_{ni} + \text{---}}{T_a} \tag{2}$$

Note n_i should be accurate to at least two decimal places.

Also compute A_1, the time averaged number of latches on all D/TV channels,

$$A_1 = \sum_{i=1}^{N_1} \bar{n}_i \tag{3}$$

and A_2, the same quantity for non-D/TV channels.

$$A_2 = \sum_{i=N_1+1}^{128} \bar{n}_i \tag{4}$$

Compute $\bar{A}_1$, the average (over channels) of A_1, and $\bar{A}_2$, the average of A_2.

$$\bar{A}_1 = \frac{A_1}{N_1} \tag{5}$$

$$A_2 = \frac{A_2}{N_2} \tag{6}$$

A_1, A_2, A_1, and A_2 should be accurate to at least two deciman places.

Note A_1 can be interpreted as the time-averaged number of monitors latched to a D/TV channel, and likewise for A_2 and non-D/TV channels. The units of these quantities are latches per channel.

The quantities T_a, A_1, A_2, A_1, and A_2 are printed out. The channel-dependent quantities n_i are printed out, along with corresponding values of $i = 1, 2, ---, 128$. Some of the n_i will be zero (unassigned channels or un-implemented channels).

Channel-Usage Summary Data

For each $i = 1, 2, ---, 128$, sum the C_{ui} for $u = 1$, i.e., sum the C_{1i}, anc call this S_{1i}.

$$S_{1i} = \sum C_{1i} \tag{7}$$

S_{1i} is not a sum on i; it is the total amount of time spent in the "in-use" condition by channel i. Although S_{0i} is not required, note that $S_{1i} + S_{0i}$ should equal T_a for each channel.

Compute P_i, the percent time that the i^{th} channel was in use, accurate to at least two decimal places.

$$P_i = \frac{100\ S_{1i}}{T_a} \tag{8}$$

Compute B_1, the average (over D/TV channels) percent time a D/TV channel was in use,

$$B_1 = \frac{1}{N_1} \sum_{i=1}^{N_1} P_i \tag{9}$$

and $\overline{B}_2$, the corresponding quantity for non-D/TV channels.

$$\overline{B}_2 = \frac{1}{N_2} \sum_{i=N_1+1}^{128} P_i \qquad (10)$$

$\overline{B}_1$ and $\overline{B}_2$ should be accurate to at least two decimal places.

The quantities $\overline{B}_1$ and $\overline{B}_2$ are printed out. The quantities P_i are printed out, along with the value of i. Some of the P_i will be zero (unassigned or un-implemented channels).

System-Usage Summary Data

Sum the D_j's for each value of $j = 0, 1, 2, ---, N_1$ and call these quantities S_j.

$$S_j = \sum D_j \qquad (11)$$

Note S_j is not a sum on j, it is the total duration of the j^{th} system state (j channels simultaneously in use) for the D/TV part of the system.

Calculate the percent time duration of each state, P_j.

$$P_j = \frac{100\ S_j}{T_a} \quad , j = 0, 1, 2, ---, N_1 \qquad (12)$$

These percentages should be accurate to at least two decimal places.

Calculate, to at least two decimal places, the weighted average $\overline{P}_j$.

$$\overline{P}_j = \frac{1}{T_a} (S_1 + 2S_2 + 3S_3 + --- + N_1 S_{N_1}) \qquad (13)$$

Note that $\overline{P}_j$ can be interpreted as the "average" (over time) system state.

As checks, $\overline{P}_j$ should equal $\frac{1}{100} \sum_{j=0}^{N_1} jP_j$

and T_a should equal $\sum_{j=0}^{N_1} S_j$

The quantity $\overline{P}_j$ is printed out. Also printed out are the P_j, along with corresponding values of j. Some of the P_j may be zero (for values of j near zero and near N_1).

6. Anomalies and Special Assumptions

In Figure 2, it is assumed that GMT_s and GMT_f do not coincide with latch changes, hence the curves in this figure are truncated on both ends. The special assumptions made here are:

(1) GMT_s is the starting time of all channel and system states and conditions existing then. This time is labeled t_1 and treated like the other t's in calculating durations. Thus t_1 (a parameter specified to DRAP) is assumed to be the starting time of the initial latch condition and channel state for each channel, as well as the starting time of the system state existing at GMT_s. In the figure, the first D_{01}, D_{22}, and D_{43}; the first C_{11}, C_{12}, and C_{13}; and the initial D_2; are all assumed to start at t_1.

(2) Likewise, GMT_f is assumed to be the finish time of all channel and system states existing just prior to this time; it is treated like the other t's in calculating durations.

If a counter technique is used, the latch counters, the channel-condition counters, and the system-state counter are all initialized at t_1 to the values existing at GMT_s. The chance of an actual latch change occurring at exactly GMT_s is very small; even so, no problem should arise since the various quantities in Table I are defined as those existing immediately after the time of a latch change.

In Section 5.1, it was stated that changes in matrix elements always occurred in pairs (i.e., involved two elements). Exceptions to this could occur if the RTCC sent a C/S word to latch a monitor to some channel, and the monitor was already latched to that channel, or if the C/S word contained an invalid channel code. In the physical system, the latter case results in completely de-latching the associated monitor from the VSM. Whether these anomalies are handled by DRIP, or even whether they can be caused by a console operator's actions, is not known.

A certain transient period must be passed through by DRIP before at least one C/S word has been received for each channel. It is possible that such transient period may not terminate before the time that the analysis starts, and hence the analysis would start with non-complete data. Even if all channels had been "heard from" by GMT_s, it would not be certain that all <u>monitors</u> had been "heard from." Thus, if a certain monitor were already latched to channel 12 at the DRIP initial time, and if it remained so latched until after GMT_f, no latch information concerning that monitor would ever be examined by DRIP, and hence that monitor's contribution to the number of latches on channel 12 would never be taken into account.

There seems to be no guaranteed solution to this problem of non-complete data. Hopefully, it will exist only during some transient period, but it may be difficult to determine when this period ends. Intuitively, the best chance of having complete matrix data by GMT_s is obtained by starting the DRIP run (and perhaps the DRAP run) as early (in terms of mission time) as possible, i.e., at the beginning of reel number 1 of the log tape. If the alternative of modifying DRIP (see Section 1) is chosen, the DRIP run must still be started with reel no. 1 of log tape, but DRAP can be started at GMT_s.

There is a test which can be made by DRAP and later interpreted by an analyst, which at least may be able to pinpoint those runs (missions) for which the matrix data was not complete at GMT_s. This is accomplished by having a DRAP routine count the number of monitors in all the elements of the matrix, i.e., add the contents of all the latch counters, at GMT_s. This number, if printed out, can be compared with the known number of monitors for that mission; if all monitors are not accounted for, there would be reason to suspect the completeness of the data at the time of starting the analysis. The routine which adds the n_i need not operate just once, it could operate every time there was a latch change. This could provide a continuous check on the validity of DRAP calculations, since this sum (total number of latched monitors) should not change once the transient period is over.

7. Suggested Report Format

The DRAP Module 5 report should contain a header section which records N_1, N_2, GMT_s, GMT_f, and the name of the mission being analyzed (in this sense, the mission name is an input parameter), as well as a format into which certain data can be entered manually. It should also contain a summary data section, in which various specified and calculated quantities are recorded. Recommended forms for these two sections are given below.

7.1 Header Information

DATA RETRIEVAL AND ANALYSIS PROGRAM (DRAP)

DRAP MODULE 5 REPORT - DISPLAY CHANNEL UTILIZATION

MISSION ________________ GMT_s ________________ GMT_f ________________

N_1 ________________ D/TV CHANNELS N_2 __________ NON-D/TV CHANNELS

(Optional) SUM OF n_i AT GMT_s ________________

EVENT	GMT MISSION TIME

7.2 Summary Data

LATCH-DISTRIBUTION DATA

T_a - ________________ A_1 ________________ A_2 ________________

$\bar{A}_1$ ________________ $\bar{A}_2$ ________________

i	$\bar{n}_i$
1	$\bar{n}_1$
2	$\bar{n}_2$
3	$\bar{n}_3$
4	$\bar{n}_4$
.	.
.	.
.	.
.	.
128	$\bar{n}_{128}$

CHANNEL - USAGE DATA

$\overline{B}_1$ ________________ $\overline{B}_2$ ________________

i	P_i
1	P_1
2	P_2
3	P_3
.	.
.	.
.	.
.	.
128	P_{128}

D/TV SYSTEM - USAGE DATA

$\overline{P}_j$ ____________

j	P_j
1	P_1
2	P_2
3	P_3
.	.
.	.
.	.
.	.
N_1	P_{N_1}

SECTION VII

ALGORITHM FOR GENERALALIZED CONSOLE/FORMAT ANALYSIS (Part I)

1. Required DRIP Input

DRIP Report 3 (abbreviated, all consoles) will provide interpretations of all Channel and Slide words (C/S words or 74_8 words) sent to the Display/Control system in response to flight controller requests, together with their GMT times of occurrence. Both select words and slide words are of interest. Those combinations of a select word and a slide word (which together constitute a display initiation response to a format or reference slide request) are of interest, and the two components of the response must be correlated, even though they occur at different times. The essential data which must be extracted from these words is as follows:

(1) Select words: GMT (designated "current time"), channel number, console number, and monitor identification.

(2) Slide words: GMT (current t), channel number, and converter or reference slide number (the converter slide number is identical with the MSK format number for a display.

Two essentially different types of information are contained in these responses: "TV Guide" information (which format is on which D/TV channel), from (2) above; and latch information (which consoles and monitors are latched to which channels and when, irrespective of whether the channels are D/TV channels or not), from (1) above. These two types of information are processed differently by DRAP,

In DRAP Analysis Module No. 5 (Section 6, pages 69 through 71) some expected anomalies and special assumptions are given. By and large, these apply in the present case also, although different quantities are involved.

In particular, the same problem of an initial transient period is expected here, since a certain amount of mission time will have to be examined before C/S words will have been received for all monitors. Hence, as in Module No. 5, the DRIP (and DRAP) initial times may have to be considerably earlier than the actual starting time of the analysis, GMT_S. The comments in the second, third and fourth paragraphs on Page 55 (Module No. 5) also apply here, except that here it is the Console/Monitor Matrix which is of interest, and here the initial times must be the same for DRIP and DRAP.

2. Gross Operation of DRAP Routines

It is anticipated that Module 6 will be programmed in two sequential parts, Part I (described here) and Part II (to be described in detail later). The information computed by Part I will be written out onto a tape which will be used as input to Part II. The same information will be printed out as a Part I report.

The block diagram of Figure 1 shows the gross operation of the DRAP routines, for both Part I and Part II of the analysis.

DRAP must do at least the following things:

(1) Examine the information described above in Section 1, paragraphs (1) and (2) and use this to construct and update a Console/Monitor Matrix, (a different version of which is maintained internal to DRIP). The elements in this matrix contain entries which are GMT times and pseudo-format numbers (see (4) below).

(2) Using information from both select words and slide words, maintain a "last latch" table by associating a given slide word with the next

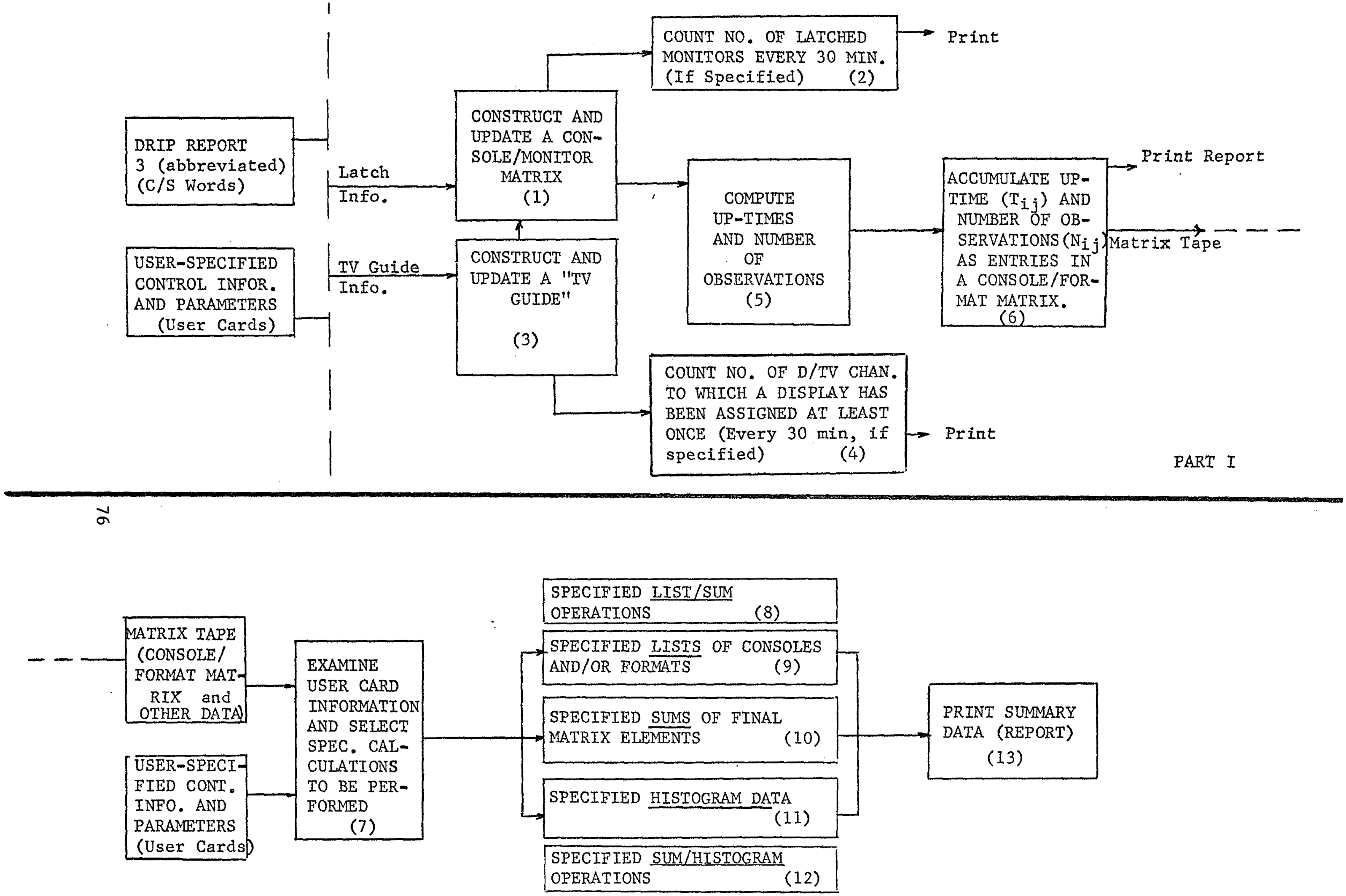


Figure 1
OPERATION OF DRAP ROUTINES

preceding select word and listing (either in this table or in the "TV Guide") the console/monitor associated with that select word, for each D/TV and/or reference slide channel.

(3) If this part of DRAP has been activated by an input user card, it will periodically (at GMT_S and at 30 minute intervals of mission time preceding GMT_S) printout the number of monitors which have received at least one latch. At these intervals, GMT time and the number of latched monitors will be printed out.

(4) Using the information described in Section 1, construct and update a table which will be called "TV Guide". This table will be large enough to list all VSM input channel numbers plus room for expansion, and will give, for each channel, the number (pseudo-format number) associated with that channel. The pseudo-format number, j, is determined from a fixed table which is constructed from data supplied on user cards, or else, if no assignment has been made, is assigned by the program. This data consists of one-to-one correspondence (arbitrarily set up by the user and different for each mission) between MSK format numbers and a set of integers, and between non-D/TV channel numbers and a set of integers. These integers are the values of j and are used (instead of MSK format numbers or VSM input channel numbers) to identify particular display formats or VSM channels in the "TV Guide." They are also used to identify both formats and non-D/TV channels in the Console/Monitor Matrix. This fixed table is printed out.

(5) If this part of DRAP has been activated by an input user card, it will periodically (at GMT_S and every 30 minutes of mission time preceding GMT_S) print out the number of D/TV channels, to which a display

has been assigned at least once since the start of the run. Since "TV Guide" entries are initialized to zeros at initial time, this amounts to counting the number of channels which have non-zero entries in the "TV Guide," although this particular counting mechanism is not required. At periodic intervals, the GMT time and the count will be printed out.

(6) At the time of arrival of any C/S word which causes a change in some entry of the Console/Monitor Matrix, the increment of <u>up-time</u> Δt of a display or channel (on the monitor(s) associated with the change) will be calculated, using the GMT's of both the current and last previous change for that monitor. In addition, immediately following any change, a count called <u>number of observations</u> will be incremented for the format/ console combination associated with that change.

(7) Quantities called T_{ij} will be accumulated as entries in a Console/Format Matrix with rows (i) corresponding to consoles and columns (j) corresponding to pseudo-format numbers. These quantities represent accumulated up-time; the up-times for each pseudo-format will, in effect, be added over all monitors associated with a given console by virtue of the way this accumulation is done.

Also accumulated in this matrix is N_{ij}, the summed (over-all monitors of a given console) number of observations for each console i and each pseudo-format j. At the end of the run, the matrix entries N_{ij} and T_{ij} will have accumulated to their final values; some of the entries of the matrix may be zero, of course. The final matrix is written on a tape at the end of the run and is also subsequently printed out as part of a report, along with other data.

The above steps constitute Part I of this analysis module, and are discussed in more detail in following sections of this document. Part II will not be discussed in detail in this document, but an indication of what the DRAP routines must do in Part II is given by the continuation below of steps (8) through (14).

(8) DRAP must examine the information supplied on certain user cards and select certain of the following operations/calculations ((9), (10), (11), (12), and (13) below) to be performed. In effect, the user can cause DRAP to do any combination of these operations/calculations upon the data in the final Console/Format Matrix (N_{ij}'s and T_{ij}'s), as well as perform certain listings. Each operation/calculation is specified by <u>type</u> and, in some cases, by <u>data</u> to be used (N_{ij}, T_{ij}, etc.). In addition, certain parameters needed to do the calculations may be specified on the Part II user cards (histogram range, etc.) and sets of values for i and j may be given which limit calculations to data having these specified subscripts.

(9) Perform certain listings of C/F matrix elements, and sum certain parts of these elements, for user-specified rows and columns.

(10) List (print out) the consoles (or formats) for which there are non-zero elements in the Console/Format Matrix in the user specified set of rows and columns.

(11) Add the N_{ij} and add the T_{ij} in all Console/Format Matrix elements lying in both the specified rows (set of values for i) and the specified columns (set of values for j). Several such sums (each over different user-specified sets of i and j) may be required; these sums are printed out.

(12) Using as data the T_{ij} or N_{ij} corresponding to user-specified sets of i and j, calculate histograms of this data, using a specified histogram range. Several such histograms (each over different user-specified sets of i and j) may be required; these histogram data are printed out.

(13) Calculate certain sums of the matrix elements, and use these as data for constructing a histogram.

(14) Print out a report which lists in suitable format all of the summary data resulting from the foregoing calculations.

3. Terminology and Example Definitions

Figure 2 and 3 provide some of the nomenclature used in subsequent discussion. They also provide the assumptions (number of consoles, monitors, formats, etc.) for an illustrative example which is worked out in following section.

Figure 2 shows the pertinent identifiers for consoles and monitors; the terminology is that of DRIP and TR-155. Each console has a console number (e.g., the Flight Dynamics Officer sat at console 11 for the GT-12 mission). These are decimal numbers, but do not form an unbroken sequence, i.e., for GT-12, there was no console 16 (or 41, 44, 51, 57, etc.). Each console also has a decimal address and an octal address; the latter is simply the octal equivalent of the former. The decimal address has been selected as the Console identifier for purposes of this algorithm, and is defined as the index i. For GT-12, i would have values 00, 01, 02, ..., 61. The decimal addresses form an unbroken sequence of numbers, hence the use of i as the row-index in the Console/Format Matrix results in a "vertically compact" matrix.

CONSOLE			MONITORS	
NUMBER	ADDRESS		DESCRIPTION	ADDRESS (k)
	Decimal (i)	Octal		
1	00	000	L,C,R	0,1,2
2	01	001	L,R	0,2
3	02	002	L,R	0,2
4	03	003	R	2
5	04	004	L	0

Figure 2
LIST OF CONSOLES AND MONITORS

PSEUDO-FORMAT NUMBER (j)	ASSIGNMENT OF j's BY USER		
	FORMATS (MSK Numbers or Slide Nos.)	VSM INPUT CHANNELS (non D/TV)	
		Chan. No.	Chan.Address (octal)
1	0003		
2	0004		
3	0531		
4	0532		
5	0617		
6	1623		
7	1624		
8		70	106
9		59	073
10		66	102

Figure 3
USER ASSIGNMENT OF PSEUDO-FORMAT NUMBERS

Note: This is the "fixed table" referred to in text and Figure 5.

The only monitors of interest here are the left (L), center (C), and right (R) console monitors; these are identified by a monitor address which is, respectively, 0, 1, and 2. This address has been selected as the monitor identifier for purposes of this algorithm, and is defined as the index k.

The particular items entered in the columns of Figure 2 are fictitious assumptions used in a subsequent example. We assume five consoles having the given identifiers for our fictitious system. These are assumed to have monitor complements shown.

Figure 3 shows an assignment of pseudo-format numbers (defined as the index j) to a fictitious set of seven display formats and three (non-D/TV) input channels of the VSM. The j's are assigned (see Section 5) for each mission by the user of DRAP. The user might have assigned the j's in many different ways from that shown; for example, he might have assigned the low values of j to channels and the higher values to formats, or he might have mixed the two insofar as the sequence of j's is concerned. The values of j form an unbroken sequence of integers 1, 2, 3, ...; hence their use as a column-index for the Console/Format Matrix results in a "laterally compact" matrix. For GT-12, the maximum value of j would be 321 (279 formats and 42 non-D/TV channels). The value of zero for j has a special (and unchanging) meaning, this value is not assigned by the user. The user makes the assignments by means of "user cards" which are read in at the time DRAP is loaded (this assignment information is also printed out as part of the Part I report).

4. Procedures for Producing Console/Format Matrix

In this section is given the detailed procedure for building up the Console/Format Matrix and for obtaining other results which are written on tape and printed out at the end of the analysis. Interwoven with the procedures is a continuation of the illustrative example begun in Section 3.

Monitor Histories

Figure 4 shows the sequence of conditions (monitor histories) assumed for the example. The events (arrivals of C/S words) which begin or terminate these conditions are shown as occurring at particular instants of GMT mission time, i.e., at GMT_s, t_1, t_2, t_3, ..., t_{24}, GMT_f. For convenience, the t's are shown with constant spacing, although this is unrealistic. The analysis time $T_a = GMT_f - GMT_s$ is calculated and printed out, as well as the user-specified GMT_s and GMT_f. For AS/204, T_a should be on the order of fifteen days.

The previously-assumed consoles and monitors are shown, together with a history for each. Arrivals of C/S words (short vertical lines randomly spaced along each monitor's time axis) are shown only during T_a, except for console 000, left monitor, which shows two of the C/S words which arrived before GMT_s and one of the words which arrived after GMT_f. Each arrival occurs at one of the t's, for example, words affecting console 001's left monitor arrived at t_6, t_{12}, t_{17}, and t_{23}. Between GMT_s and t_6, this monitor was showing pseudo-format 1 (which is seen to be MSK format 0003 from Figure 3). The subscript indicates that this format was on Channel 3 at the time. Between t_6 and t_{12}, this monitor was showing pseudo-format 5 (MSK format 0617), which was on Channel 4

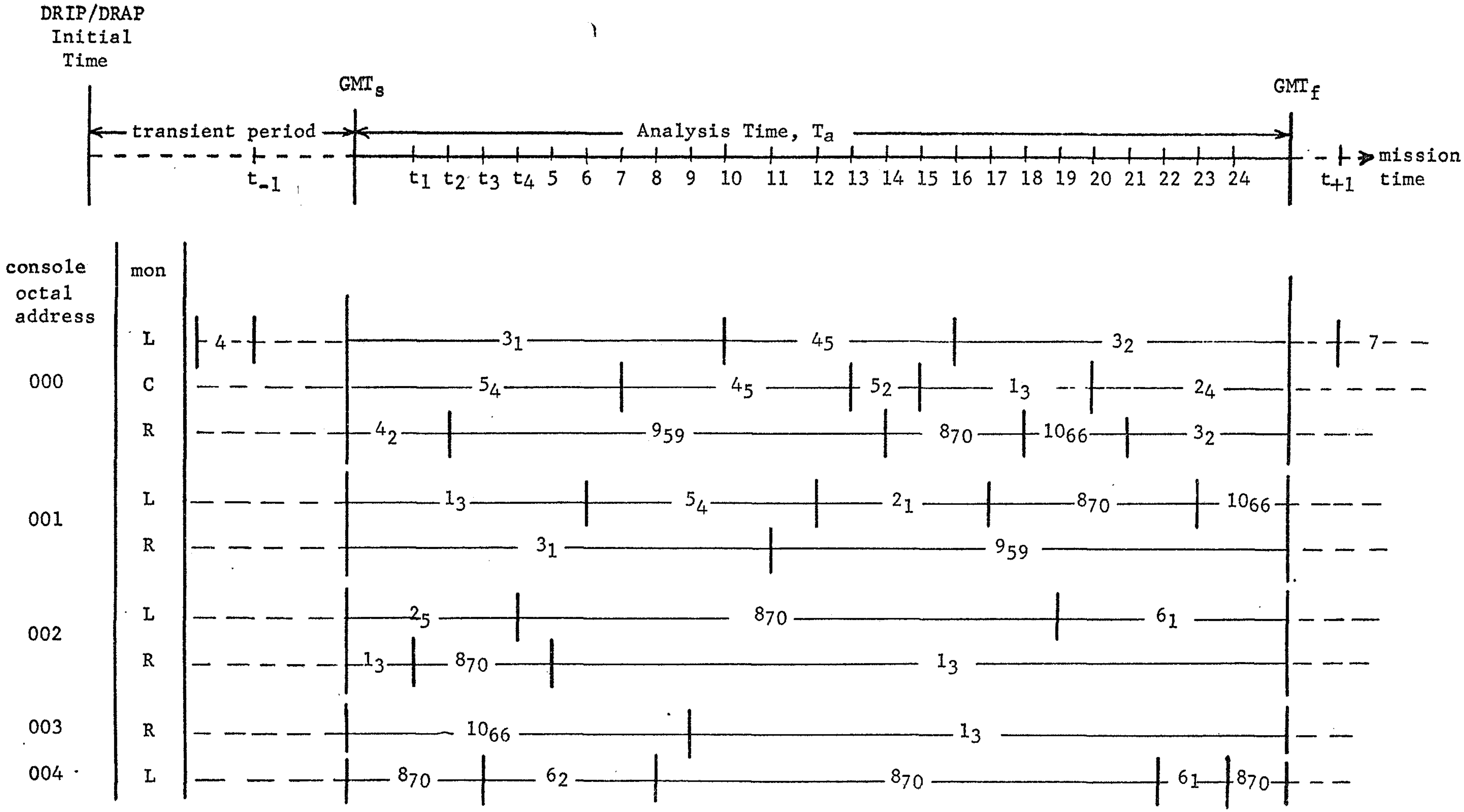


Figure 4. MONITOR HISTORIES

Numbers are pseudo format numbers (j's);
Subscripts indicate D/TV channel the format
is on (for j = 1,...,7), or VSM channel no.
corresponding to that value of j(for j=8,9 or 10)

at the time. Between t_{12} and t_{17}, this monitor was showing pseudo-format 2 (MSK format 0004), which was on Channel 1. Between t_{17} and t_{23}, this monitor was showing pseudo-format 8 (whatever was on channel 70, but not a display format); the subscript in this case indicates the non-D/TV channel to which j = 8 was assigned in Figure 3. Between t_{23} and GMT_f, this monitor was showing pseudo-format 10 (i.e., it was latched to channel 66).

The C/S words arriving outside of T_a (three of which are shown for console 000, left monitor) affect DRAP as follows:

(1) Words arriving between DRIP/DRAP initial time and GMT_s affect the buildup of "TV Guide" and Console/Monitor Matrix (C/M Matrix) entries during this period. Thus it is necessary that DRAP process all of these words, in order that the C/M Matrix and "TV Guide" be complete at GMT_s.

(2) Up-time and number of observations need not be calculated before GMT_s, hence the part of the program which does this need not operate prior to GMT_s.

(3) The first word arriving after GMT_f (no matter which monitor it is associated with) will cause a termination of the process of building up the Console/Format Matrix (C/F Matrix), hence this word must be processed. Subsequent words are not processed.

(4) When a word occurring before GMT_s initiates a monitor condition which persists beyond GMT_s (i.e., is terminated within T_a), the increment of up-time associated with that condition is the portion of total up-time lying within T_a. For example, if the word shown arriving just before GMT_s for console 000L is at time t_{-1}, the up-time calculated by DRAP is t_{10} - GMT_s. Notice that, by the foregoing rules, the Latch of console

000L to pseudo-format 4 (which is terminated at t_{-1}) does not contribute an increment to up-time or to number of observations, although it does affect the C/M Matrix and the "TV Guide."

(5) In the usual case, all monitor conditions existing at GMT_f will persist beyond GMT_f; an example is the latch of 000L to pseudo-format 3 which is not terminated until t_{+1}. The increment of up-time calculated in such a case is that portion of total up-time lying within T_a; e.g., $GMT_f - t_{16}$. If the word at t_{+1} was the first word occurring after GMT_f, it would initiate the calculation of final increments for all monitors.

Partial Flow Chart

Figure 5 (on four pages) shows an example of how some of the foregoing rules might be imbedded in a flow chart. The chart also illustrates specific ways in which some of the calculations might be accomplished, but does not show all of the things which DRAP must do in Part I. Further, some of the boxes are summarized and must themselves be expanded into flow charts.

The sequence of actions shown is initiated by the occurrence of a C/S word on the DRIP tape being used as input to DRAP. The time of occurrence is designated "current t" and is one of the t's illustrated in Figure 4. Also available from DRIP is the octal address of the destination console, the monitor identification (L, C, R), the channel number, the reference slide number (if any), and the converter slide number (if any); the latter is also the MSK format number. The specific set of actions taken for a given word depends on the nature of these word parameters, as follows:

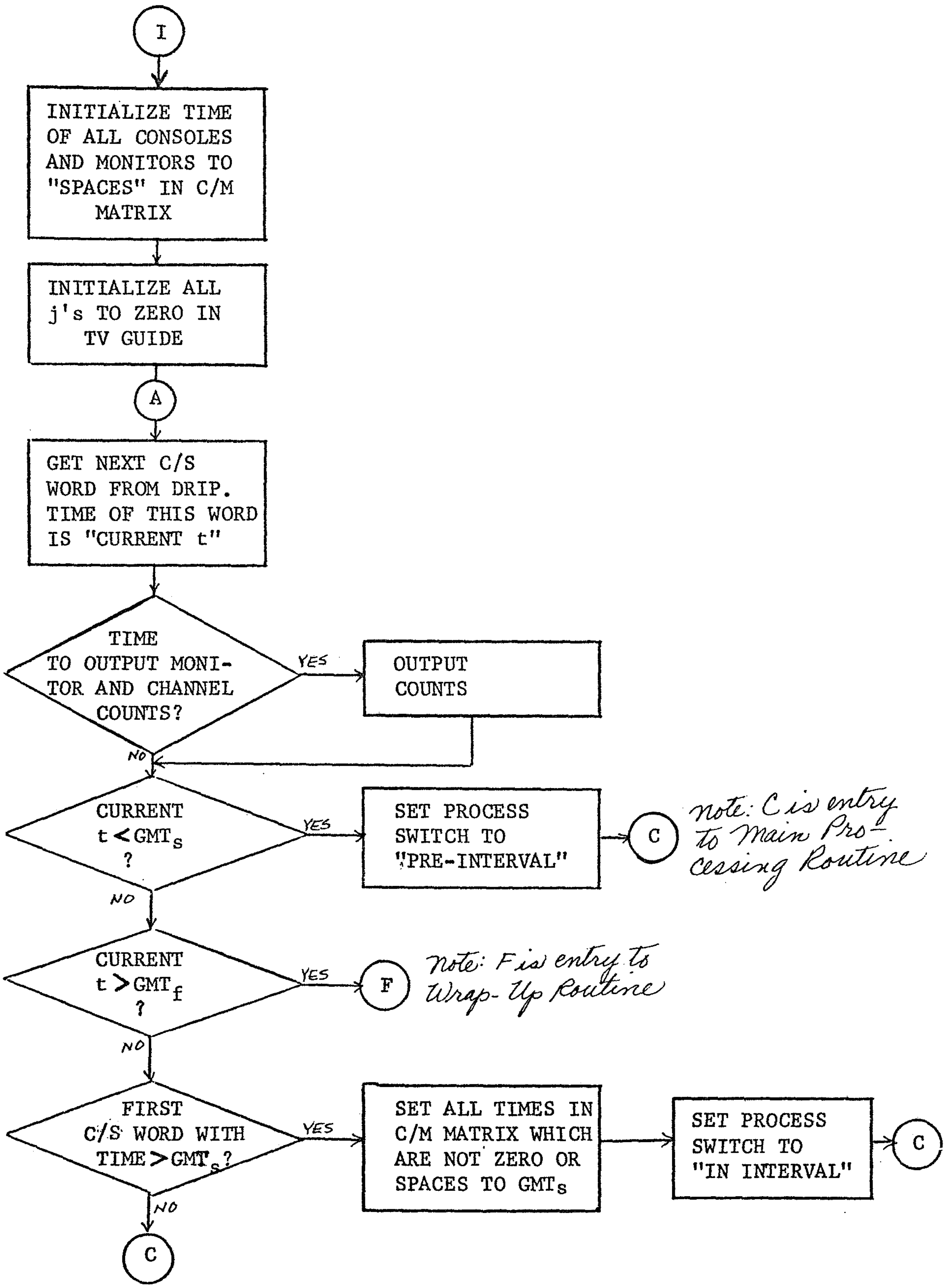


Figure 5. PARTIAL FLOW CHART

Figure 5 (continued)

MAIN PROCESSING ROUTINE

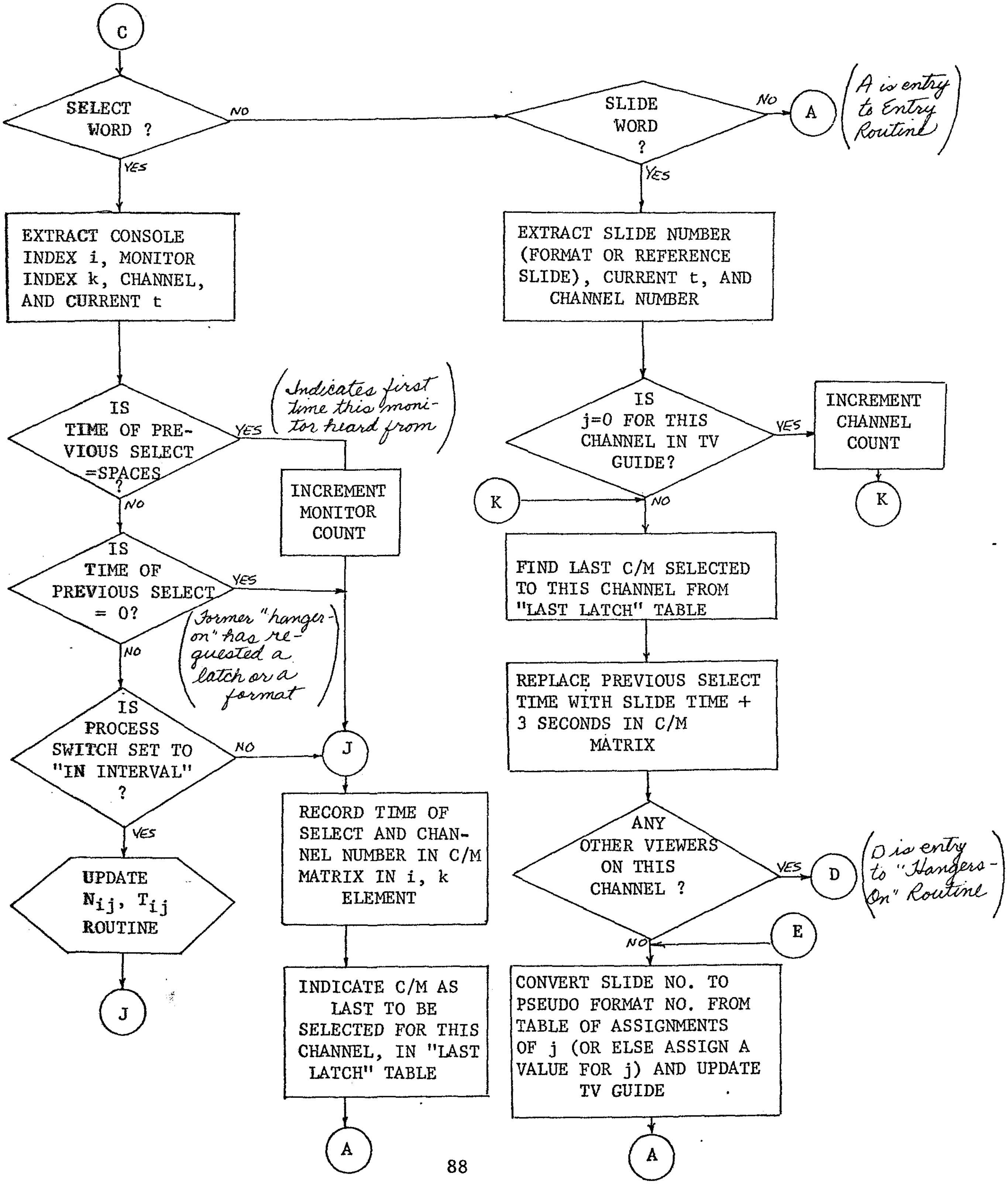


Figure 5 (continued)

UPDATE N_{ij}, T_{ij} ROUTINE

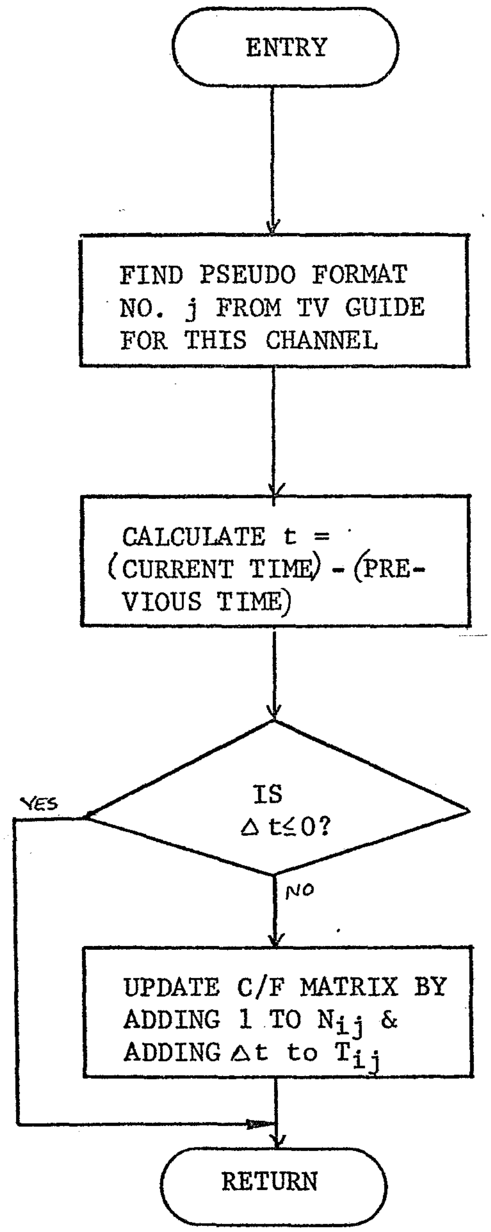
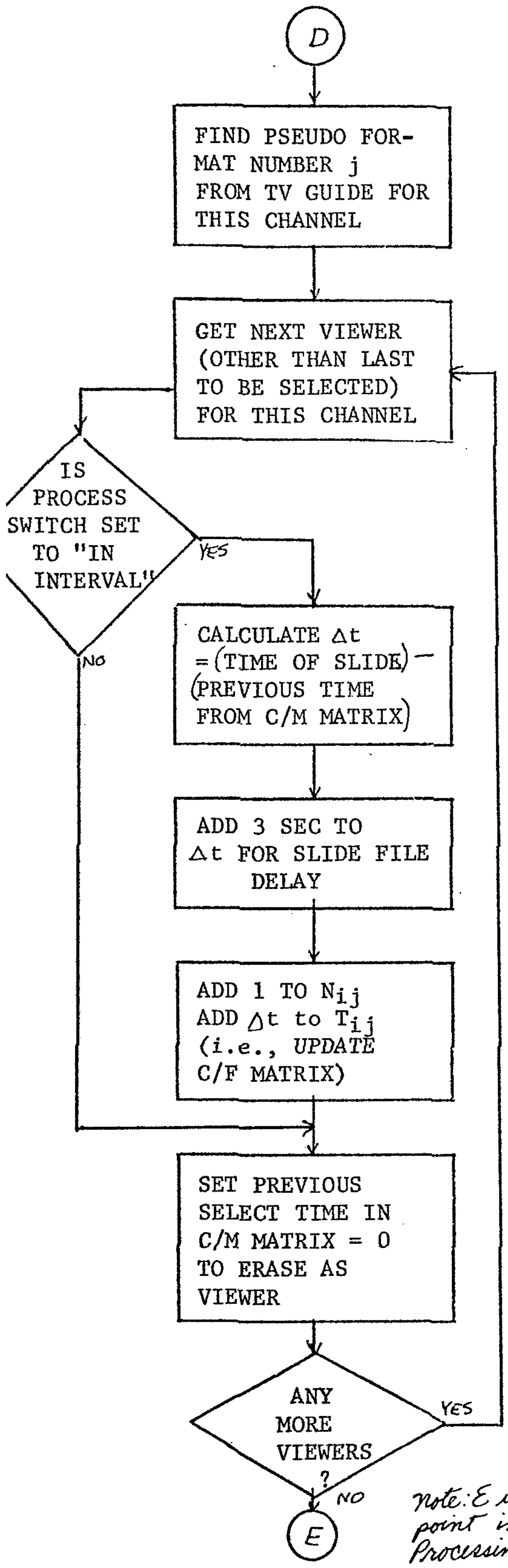


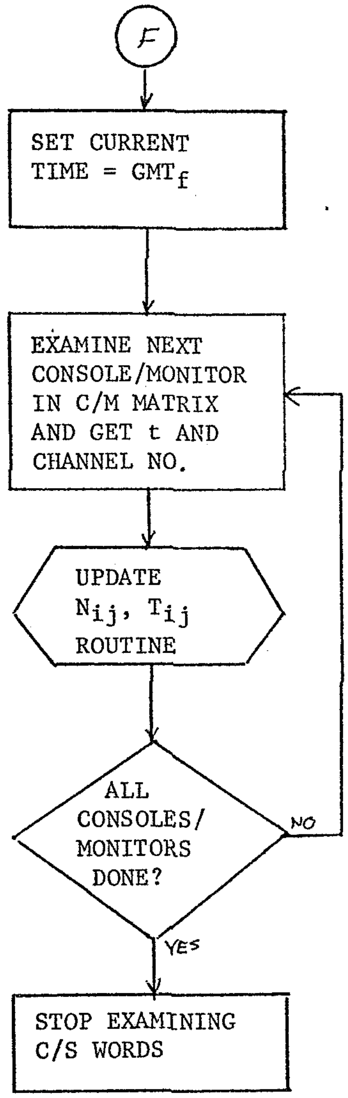
Figure 5 (continued)

"HANGERS-ON" ROUTINE



Note: E is an entry point in Main Processing Routine

WRAP-UP ROUTINE



(1) If current $t < GMT_s$, a switch is set to "pre-interval" and entries continue to be made in the C/M Matrix and "last latch" table.

(2) If $GMT_s \leq$ current $t \leq GMT_f$ (implied by an "in interval" switch setting) the various matrices and tables continue to be updated, and in addition, the Console/Format Matrix elements N_{ij} and T_{ij} are incremented.

(3) If current $t > GMT_f$ then a "wrap-up" routine does final processing for all monitors. Note that the value of i at each cycle of the Wrap-Up routine is supplied by the code controlling the looping.

One of the many details not covered by Figure 5 is that no provision is made in the flow chart for rejecting C/S words which specify a "monitor" other than L, C, or R (e.g., LPTV, etc.); some such provision must be made.

C/M Matrix and "TV Guide"

The Console/Monitor Matrix has three columns (index k) which represent the three monitor addresses of interest (L, C, R or k=0, 1, 2). It has a number of rows (index i) determined by the number of consoles in the system (62 for third floor, GT-12). In a following Figure, the elements of this matrix are specified by i and k; e.g., the "0, 2 entry" refers to the entry in the element located in row 0 and column 2 (or for i = 0 and k = 2). In the example, this element and the entry therein would pertain to console 000, right monitor. The entry in each element consists of a pseudo-format number and a time (time of previous select or "previous time" in Figure 5).

The "TV Guide" is visualized as a table having at least as many rows as there are VSM input channels (70 as of GT-12), and space for one entry

Figure 6

Translation made using Figs. 4 & 5

MISSION TIME (t's)	INFORMATION CONTAINED IN C/S WORD*		CHANGES MADE TO:	
	"TV Guide" Information	Latch Information	"TV Guide"	C/M Matrix
initial times			Initialize all entries to zero.	
GMT_s	Assume no C/S word at GMT_s	Assume no C/S word at GMT_s	None	None
t_1	None	Latch Console 002R to channel 70	None	Change all t's in C/M Matrix to GMT_s. Change 2,2 entry to 8, t_1
2	None	Latch Console 000R to channel 59	None	change 0,2 entry to 9, t_2
3	Assign format 1623 to Chann. 2	Latch Con. 004L to Chann. 2.	Change Chann. 2 entry to 6	Change 4,0 entry to 6, t_3
4	None	Latch Con. 002L to Chann. 70	None	Chg. 2,0 entry to 8, t_4
5	None	Latch Con. 002R to Chann. 3	None	Chg. 2,2 entry to 1, t_5
6	None	" 001L " 4	None	" 1,0 " 5, t_6
7	Assign format 0532 to Chann. 5	" 000C " 5	Change Chann. 5 entry to 4	" 0,1 " 4, t_7
8	None	" 004L " 70	None	" 4,0 " 8, t_8
9	None	" 003R " 3	None	" 3,2 " 1, t_9
10	None	" 000L " 5	None	" 0,0 " 4, t_{10}
11	None	" 001R " 59	None	" 1,2 " 9, t_{11}
12	Assign format 0004 to Chann. 1	" 001L " 1	Change Chann. 1 entry to 2	" 1,0 " 2, t_{12}
13	'	'	'	'
14	'	'	'	'
15	'	'	'	'
16	'	'	'	'
17	'	'	'	'
18	'	'	'	'
19	'	'	'	'
20	'	'	'	'
21	'	'	'	'
22	'	'	'	'
23	'	'	'	'
24	None	Latch 004L to Chan 70	None	Chg. 4,0 Entry to 8, t_{24}
GMT_f	None	None	None	None

*Expressed in terms of MSK format numbers, VSM input channel numbers, and octal console addresses.

(pseudo-format number) in each row. The "last latch" information could also be recorded here, instead of in a separate table. The entries are continually being overwritten and/or read out as mission time increases, hence any representation of the "TV Guide" would have the nature of a "snapshot" at some particular instant of time. Note that when processing any given C/S word, the "TV Guide" must be updated <u>before</u> it is used to provide a value of j; this condition is satisfied by the flow chart of Figure 5.

Figure 6 continues the example by illustrating the results of processing the data of Figure 4 via the operations of Figure 5. It shows, as a function of time, the changes which would be made in the C/M Matrix and the "TV Guide". Note that in Figure 6, the select and slide information is assumed to arrive simultaneously (at one of the t's); this is not actually the case and hence Figure 6 can be used only to get a very general picutre of the sequence of events.

Continuing the example, Figure 7 shows the appearance of the C/M Matrix at three specific instants of time, under the assumed conditions. These "snapshots" can be derived from Figure 1.

Figure 8 shows the assumed history of assignment of formats by the RTCC to D/TV channels; this assumption underlies the histories shown in Figure 4 and is consistent with them. The duration of each format on a given channel is shown in two segments: the time during which at least one monitor is latched to the channel and the time during which no monitor is latched to the channel. DRAP makes no distinction between these two channel conditions.

This figure is based on an assumption of five D/TV channels in our hypothetical system, and is included for background only. To illustrate the meaning of the figure, it shows that at GMT_s, format (pseudo-format) 3 was on Channel 1, format 4 was on Channel 2, 1 was on 3, 5 was on 4, and 2 was on 5. Beginning at t_2 and continuing until t_7 (See Figure 4), no monitors were latched to format 4, hence the history of this format on Channel 2 is shown as a dashed line from t_2 until t_3 when the RTCC assigned format 5 to this channel. Format 4 was subsequently (at t_7) assigned to Channel 5. A "snapshot" of the "TV Guide" (actually, that part of the "TV Guide" comprised of the D/TV channels) is obtained at any given time by reading across the columns of Figure 8 at that time and noting which format was on each channel. As indicated, this was done for three instants of time: GMT_s, t_{12}, and GMT_f; the results are shown in Figure 9.

Also shown in Figure 9 is the D/TV part of the "TV Guide" at initial time (before processing the first C/S word but after initialization to all zeros).

Console/Format Matrix

As each C/S word is processed, not only are changes made to the C/M matrix (and perhaps the TV Guide), but increments of up-time $\triangle T_{ij}$

(a) At first t $>GMT_s$

		Mon: L k: 0	C 1	R 2
i	Dec. Console Add.			
0	00	3, GMT_s	5, GMT_s	4, GMT_s
1	01	1, GMT_s		3, GMT_s
2	02	2, GMT_s		8, t_1
3	03			10, GMT_s
4	04	8, GMT_s		

(b) At t_{12}

		Mon: L k: 0	C 1	R 2
i	Dec. Console Add.			
0	00	4, t_{10}	4, t_7	9, t_2
1	01	2, t_{12}		9, t_{11}
2	02	8, t_4		1, t_5
3	03			1, t_9
4	04	8, t_8		

(c) At GMT_f

		Mon: L k: 0	C 1	R 2
i	Dec. Console Add.			
0	00	3, t_{16}	2, t_{20}	3, t_{21}
1	01	10, t_{23}		9, t_{11}
2	02	6, t_{19}		1, t_5
3	03			1, t_9
4	04	8, t_{24}		

Figure 7
CONSOLE/MONITOR MATRIX

The matrix is shown at three instants of time. The time in each entry denotes start of conditions shown (i.e., start of latch of that monitor to the pseudo format number shown).

CHANNEL HISTORIES

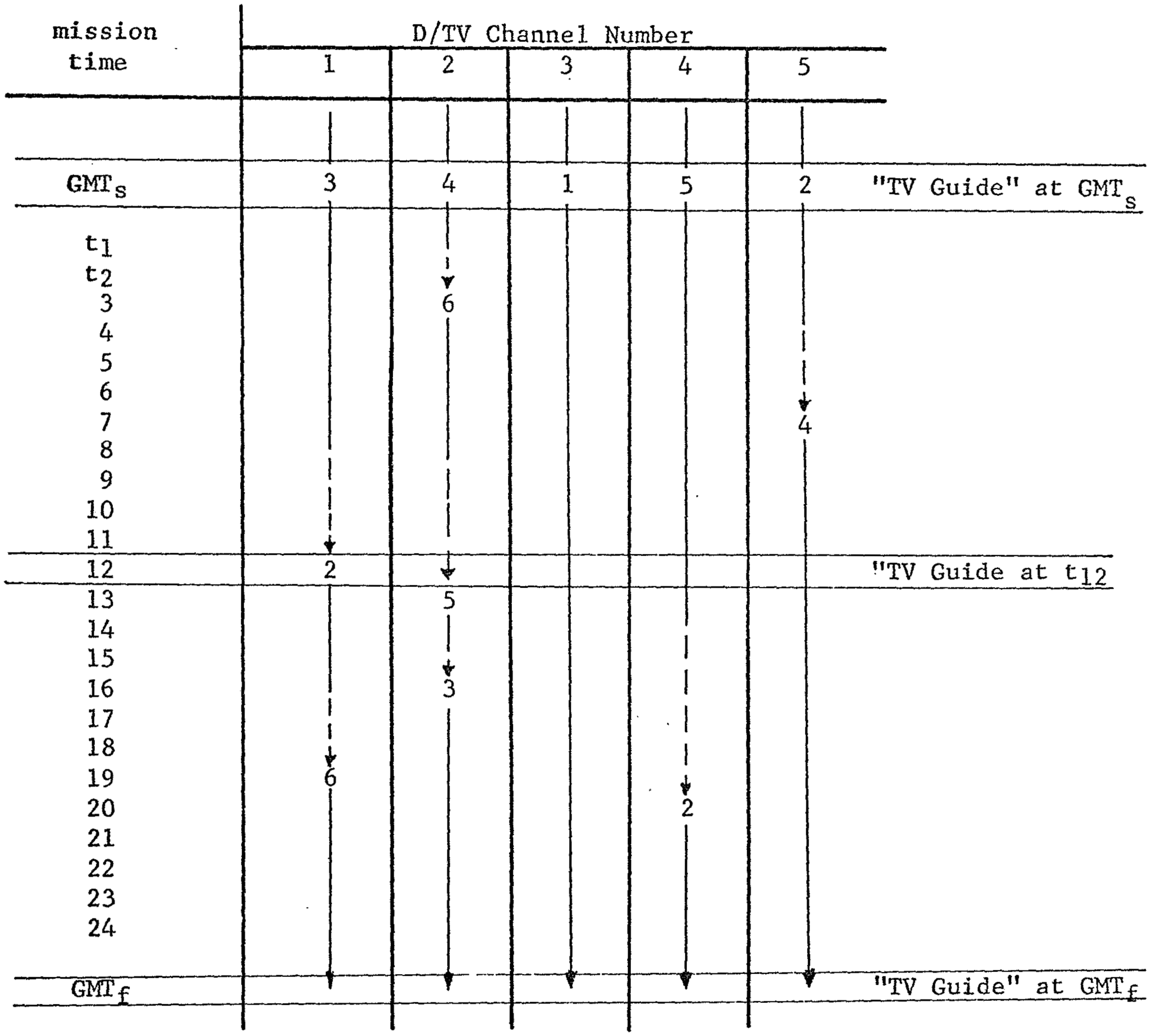


Figure 8

CHANNEL HISTORIES

Entries are pseudo-format numbers representing displays assigned to the channels by RTCC. Solid lines indicate monitor(s) latched to channel (display is being updated); dashed lines indicate no monitor(s) latched to channel (display is not being updated).

D/TV Channel	Display Format on Channel (Pseudo-Format Number)
1	0
2	0
3	0
4	0
5	0

(a) At Initial Time

D/TV Channel	Display Format on Channel (Pseudo-Format Number)
1	3
2	4
3	1
4	5
5	2

(b) At GMT_s

D/TV Channel	Display Format on Channel (Pseudo-Format Number)
1	2
2	6
3	1
4	5
5	4

(c) At t_{12}

D/TV Channel	Display Format on Channel (Pseuo -Format Number)
1	6
2	3
3	1
4	2
5	4

(d) At GMT_f

Figure 9
"TV GUIDE" AT VARIOUS TIMES
(Showing D/TV channels only)

and number of observations ΔN_{ij} are calculated and added to the proper entry in the Console/Format Matrix (C/F Matrix). These matrix entries, T_{ij} and N_{ij}, thus accumulate to their final values shortly after GMT_f, at which time the matrix is printed out. It is also written on a tape, called the "matrix tape", for input to Part II. This tape contains data in addition to the C/F matrix.

The C/F Matrix is envisioned as a rectangular two-dimensional matrix with row index i (console) and column-index j (pseudo-format), and with elements containing two types of entry: the T_{ij} or accumulated up-time for pseudo-format j on console i, and the N_{ij} or accumulated number of observations of pseudo-format j on console i. As indicated in the flow chart of Figure 5, ΔN_{ij} is always equal to 1, and Δt is equal to the difference between "previous t" and current t, both being calculated for one of the monitors physically located in console i. The N_{ij} are dimensionless, and the T_{ij} are in decimal hour notation (e.g., 191.7863 hours) and must be accurate to the nearest ten-thousandth of an hour. In Part II, the N_{ij} and T_{ij} will be operated upon numerically.

An upper bound for the final value of a T_{ij} is the analysis time T_a. A <u>guess</u> as to an upper bound for the final value of an N_{ij} is twenty per hour of analysis time (if T_a is fifteen days, this would yield a worst-case final value for an N_{ij} of 7200).

Continuing the example, Figures 10, 11, 12, and 13 illustrate the buildup of the C/F Matrix under the assumed conditions. Note that these figures are based on Figure 6, which in turn is based on the assumption that select and slide information arrive simultaneously, hence the times shown are only grossly correct in some cases. Figure 10 shows a time history of all changes made to the matrix, with N's and T's identified as to console and pseudo-format. In calculating the T's, the t's of Figure 4 are assumed to be equally spaced, by one unit of time, along the time axis (except for t_1 and t_{24}, which are assumed to be two time units from GMT_s and GMT_f, respectively). The T's are thus in arbitrary "units" of time for this example. To illustrate, console 0's left monitor showed pseudo-format 4 from t_{10} to t_{16}, hence the associated up-time increment ΔT_{04} is $t_{16} - t_{10}$, which is equal to six units of time; this is entered in Figure 10 at t_{16}.

Figure 11 shows the changes of Figure 10, but arranged by console and given in terms of cumulative values. For example, console 0 viewed pseudo-format 4 three times during T_a, once on each of its three monitors. The corresponding changes in N_{04} and T_{04} are shown at t_2, t_{13}, and t_{16}, as are the cumulative values. As can be seen, N_{04} accumulates to 3, and T_{04} accumulates to 13, during T_a. These two numbers would thus be values in the final C/F Matrix.

Figure 12 shows the values of N_{ij} and T_{ij} at various instants of time for console 0 and all of the formats viewed at that console; this figure is essentially another way of displaying the data in the first main column of Figure 11, except that it shows accumulated values only. It shows, at GMT_f, the final values of the N's and T's for this console, hence the last row of the figure gives the data found in one row (the one for console 0) of the final C/F Matrix. If Figure 12 were done for each of our five hypothetical consoles, the last rows of these figures would furnish all the data for the final C/F Matrix, which would then appear as in Figure 13. Note that Figure 13 does not show the data

Figure 10
EXAMPLE HISTORY OF CHANGES MADE TO
CONSOLE/FORMAT MATRIX DURING T_a

Note: In calculating T_{ij} increments, assume that sequential t's differ by 1 unit of time, e.g., $t_x - t_{x-1} = 1$. Assume that GMT_s and GMT_f are spaced by two units of time from the nearest t.

MISSION TIME (t's)	CHANGES MADE TO ENTRIES IN C/F MATRIX	
	N_{ij}	T_{ij} (See Note)
GMT_s	Set all $N_{ij} = 0$	Set all $T_{ij} = 0$
t_1	Add 1 to N_{21}	Add 2 to T_{21}
t_2	1 N_{04}	1 T_{04}
3	1 N_{48}	4 T_{48}
4	1 N_{22}	5 T_{22}
5	1 N_{28}	4 T_{28}
6	1 N_{11}	7 T_{11}
7	1 N_{05}	8 T_{05}
8	1 N_{46}	5 T_{46}
9	1 $N_{3,10}$	10 $T_{3,10}$
10	1 N_{03}	11 T_{03}
11	1 N_{13}	12 T_{13}
12	1 N_{15}	6 T_{15}
13	1 N_{04}	6 T_{04}
14	1 N_{09}	12 T_{09}
15	1 N_{05}	2 T_{05}
16	1 N_{04}	6 T_{04}
17	1 N_{12}	5 T_{12}
18	1 N_{08}	4 T_{08}
19	1 N_{28}	15 T_{28}
20	1 N_{01}	5 T_{01}
21	1 $N_{0,10}$	3 $T_{0,10}$
22	1 N_{48}	14 T_{48}
23	1 N_{18}	6 T_{18}
24	1 N_{46}	2 T_{46}
GMT_f	1 N_{03}	10 T_{03}
	1 N_{02}	6 T_{02}
	1 N_{03}	5 T_{03}
	1 $N_{1,10}$	3 $T_{1,10}$
	1 N_{19}	15 T_{19}
	1 N_{26}	7 T_{26}
	1 N_{21}	21 T_{21}
	1 N_{31}	17 T_{31}
	1 N_{48}	2 T_{48}

Figure 11
HISTORY OF CHANGES TO CONSOLE/FORMAT
MATRIX ENTRIES, ARRANGED BY CONSOLE

Notes: Values of N_{ij} are absolute numbers, values of T_{ij} are in arbitrary "time units" for convenience.

CONSOLE (i)

Mission Time	0		1		2		3		4	
	N_{0j}	T_{0j}	N_{1j}	T_{1j}	N_{2j}	T_{2j}	N_{3j}	T_{3j}	N_{4j}	T_{4j}
GMT_s										
t_1					$N_{21}=0+1=1$	$T_{21}=0+2=2$				
2	$N_{04}=0+1=1$	$T_{04}=0+1=1$								
3									$N_{48}=0+1=1$	$T_{48}=0+4=4$
4					$N_{22}=0+1=1$	$T_{22}=0+5=5$				
5					$N_{23}=0+1=1$	$T_{23}=0+4=4$				
6			$N_{11}=0+1=1$	$T_{11}=0+7=7$						
7	$N_{05}=0+1=1$	$T_{05}=0+8=8$								
8									$N_{46}=0+1=1$	$T_{46}=0+5=5$
9							$N_{3,10}=0+1=1$	$T_{3,10}=0+10=10$		
10	$N_{03}=0+1=1$	$T_{03}=0+11=11$								
11			$N_{13}=0+1=1$	$T_{13}=0+12=12$						
12			$N_{15}=0+1=1$	$T_{15}=0+6=6$						
13	$N_{04}=1+1=2$	$T_{04}=1+6=7$								
14	$N_{09}=0+1=1$	$T_{09}=0+12=12$								
15	$N_{05}=1+1=2$	$T_{05}=8+2=10$								
16	$N_{04}=2+1=3$	$T_{04}=7+6=13$								
17			$N_{12}=0+1=1$	$T_{12}=0+5=5$						
18	$N_{08}=0+1=1$	$T_{08}=0+4=4$								
19					$N_{23}=1+1=2$	$T_{23}=4+15=19$				
20	$N_{01}=0+1=1$	$T_{01}=0+5=5$								
21	$N_{0,10}=0+1=1$	$T_{0,10}=0+3=3$								
22									$N_{48}=1+1=2$	$T_{48}=4+14=18$
23			$N_{18}=0+1=1$	$T_{18}=0+6=6$						
24									$N_{46}=1+1=2$	$T_{46}=5+2=7$
GMT_f	$N_{03}=1+1+1=3$ $N_{02}=0+1=1$	$T_{03}=11+10+5=26$ $T_{02}=0+6=6$	$N_{1,10}=0+1=1$ $N_{19}=0+1=1$	$T_{1,10}=0+3=3$ $T_{19}=0+15=15$	$N_{26}=0+1=1$ $N_{21}=1+1=2$	$T_{26}=0+7=7$ $T_{21}=2+21=23$	$N_{31}=0+1=1$	$T_{31}=0+17=17$	$N_{48}=2+1=3$	$T_{48}=18+2=20$

Table 12

PARTIAL HISTORY OF N_{ij} AND T_{ij} AS ACCUMULATED
IN CONSOLE/FORMAT MATRIX
(for i = 0 and j = 1, 2, 3, 4, 5, 8, 9, and 10 only)

CONSOLE 0

Mission Time (t's)	Formats (Pseudo-Format Numbers															
	1		2		3		4		5		8		9		10	
	N_{01}	T_{01}	N_{02}	T_{02}	N_{03}	T_{03}	N_{04}	T_{04}	N_{05}	T_{05}	N_{08}	T_{08}	N_{09}	T_{09}	$N_{0,10}$	$T_{0,10}$
GMT_s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
t_1																
2							1	1								
3																
4																
5																
6																
7									1	8						
8																
9																
10					1	11										
11																
12																
13							2	7								
14													1	12		
15									2	10						
16							3	13								
17																
18											1	4				
19																
20	1	5														
21															1	3
22																
23																
24																
GMT_f	1	5	1	6	3	26	3	13	2	10	1	4	1	12	1	3

NOTE: This history reflects only those matrix entries for console 0 and for the formats viewed at that console.

for Column 0. No latches to pseudo-format 0 are assumed in this example, hence the final matrix would have all zeros in its first column.

The final C/F Matrix in Figure 13 is a representation only, and is not meant to define the form in which this matrix appears in the computer. The computer form of the matrix would have to contain all of the numerical values for N_{ij} and T_{ij}, arranged in such a way that they could be located by specifying i and j.

The matrix as shown contains a number of "blank" elements (such as the element for i = 1, j = 4); these represent console-format combinations which never occurred during the analysis and hence were never filled in with entries. These blank elements may or may not be physically represented by certain core locations in the computer, depending on the way in which the programming is done. If not, an obvious saving in core can be accomplished, since the matrix is expected to have a large number of blank elements.

On the other hand, these blank elements "contain" essential information, namely, that the N's and T's associated with them are all equal to zero. This is indicated in the 0, 6 and 0, 7 elements where instead of leaving the element blank, this essential information is shown in parentheses. If it is possible to do the programming such that these zero values of N and T can be inferred from the matrix form written in core (inferred either by DRAP Part II from the matrix tape, or by the user who sees a printout), then core need not be used up for these blank elements.

To repeat: it is necessary that all zero values of N_{ij} and T_{ij} be obtainable (directly or by inference) from the final matrix form as it is printed or as written on tape. These zero values are legitimate values,

Figure 13
FINAL CONSOLE/FORMAT MATRIX (FOR EXAMPLE)

Console Number (i)	Pseudo Format Number (j) 1	2	3	4	5	6	7	8	9	10
0	$N_{01}=1$ $T_{01}=5$	$N_{02}=1$ $T_{02}=6$	$N_{03}=3$ $T_{03}=26$	$N_{04}=3$ $T_{04}=13$	$N_{05}=2$ $T_{05}=10$	$(N_{06}=0)$ $(T_{06}=0)$	$(N_{07}=0)$ $(T_{07}=0)$	$N_{08}=1$ $T_{08}=4$	$N_{09}=1$ $T_{09}=12$	$N_{0,10}=1$ $T_{0,10}=3$
1	$N_{11}=1$ $T_{11}=7$	$N_{12}=1$ $T_{12}=5$	$N_{13}=1$ $T_{13}=12$		$N_{15}=1$ $T_{15}=6$			$N_{18}=1$ $T_{18}=6$	$N_{19}=1$ $T_{19}=15$	$N_{1,10}=1$ $T_{1,10}=3$
2	$N_{21}=2$ $T_{21}=23$	$N_{22}=1$ $T_{22}=5$				$N_{26}=1$ $T_{26}=7$		$N_{28}=2$ $T_{28}=19$		
3	$N_{31}=1$ $T_{31}=17$									$N_{3,10}=1$ $T_{3,10}=10$
4						$N_{46}=2$ $T_{46}=7$		$N_{48}=3$ $T_{48}=20$		

and may be used in the calculations of Part II. Note that Figure 13 shows a matrix column for every pseudo-format specified by the user, even though one of these (pseudo-format 7) was never viewed by any console.

5. User Cards

Before each run of DRAP 6 (Part I) the user must supply certain information which is then punched into cards ("user cards") for input along with DRAP. The user should be provided with a standard page-size form for filling in this information; the arrangement of this form should facilitate punching of the information into cards. Most of this user-supplied data is to be printed out as part of the Part I report; in addition it is used by DRAP to enable or disable certain routines, and as a source of numbers needed for certain translations and calculations. The data to be specified by the user is described below under several categories, without regard to format; note that cards related to A, B, C, and D have the nature of adaptation cards specific to one mission.

A. Mission Identification

The name and number of the mission being analyzed; e.g., GT-9, GT-12, AS-204, etc.

B. Mission Times

The start and stop times of the analysis; i.e., GMT_s and GMT_f in day-hour-minute-second notation.

C. Activation of Counting Routines

A binary indication (yes or no) as to whether each of the two count-output routines is to be activated for this particular DRAP run. The indication will be given for both the "monitor count" and the "Channel count". The former prints out the number of monitors for which there are entries (non-"blank" elements) in the Console/Monitor Matrix, and the latter prints out the number of D/TV channels which have been assigned at least one format since the start of examining C/S words. The count and GMT time-of-count are printed out every 30 minutes of mission time prior to GMT_S, and every time there is a change in either count after GMT_S.

D. User Assignment of Pseudo-Format Numbers

In order to facilitate the operation of DRAP, the following procedure is suggested for the user when assigning pseudo-format numbers.

The user will list, in ascending order, the numbers of the non-D/TV channels available for this particular mission, followed in each case by a pseudo-format number, j. The user will assign sequential values of j beginning with 1 in this part of the list.

The user will next list, in ascending order, the MSK format numbers available for this particular mission, followed in each case by a pseudo-format number, so as to continue the unbroken sequence of j's started above. The user may also continue in this manner for reference slide numbers, if desired, but these should be identified as such.

Note that in Figure 3 the user did not follow the above procedure in that he assigned j's to formats first and then to channels. A completely random and arbitrary assignment might require DRAP to sort and order before entering the data in a table for subsequent look-up.

DATA RETRIEVAL AND ANALYSIS PROGRAM (DRAP)

DRAP MODULE 6 REPORT - GENERALIZED CONSOLE/FORMAT ANALYSIS. PART I - CONSOLE/FORMAT MATRIX

MISSION ________________ GMT_s ______________ GMT_f ________________

T_a ________________ANALYSIS TIME N_1 __________D/TV CHANNELS

USER ASSIGNMENT OF PSEUDO-FORMAT NUMBERS

CHANNEL OR FORMAT	J
________________	____
________________	____
________________	____
________________	____
________________	____
⋮	⋮

MONITOR COUNT		CHANNEL COUNT	
TIME	COUNT	TIME	COUNT
_____	_______	_____	______
_____	_______	_____	______
_____	_______	_____	______
_____	_______	_____	______
⋮	⋮	⋮	⋮

CONSOLE/FORMAT MATRIX

i \ j	0		1		2		3		4		
0	N_{00}	T_{00}	N_{01}	T_{01}	N_{02}	T_{02}	N_{03}	T_{03}	N_{04}	T_{04}	. . .
1	N_{10}	T_{10}	N_{11}	T_{11}	N_{12}	T_{12}	N_{13}	T_{13}	N_{14}	T_{14}	. . .
2	N_{20}	T_{20}	N_{21}	T_{21}	N_{22}	T_{22}	N_{23}	T_{23}	N_{24}	T_{24}	. . .
3	N_{30}	T_{30}	N_{31}	T_{31}	N_{32}	T_{32}	N_{33}	T_{33}	N_{34}	T_{34}	. . .
4	N_{40}	T_{40}	N_{41}	T_{41}	N_{42}	T_{42}	N_{43}	T_{43}	N_{44}	T_{44}	. . .
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	

SECTION VIII

ALGORITHM FOR GENERALIZED CONSOLE/FORMAT ANALYSIS
(Part II)

1. Required Input

The input to Part II consists physically of a tape (the "matrix tape") produced by Part I of DRAP 6, and a number of control cards, as described below.

The matrix tape contains the following data, all of which was either produced by, or entered by the user into, Part I (see report format for Part I):

(1) Mission identification.

(2) GMT_s, GMT_f, N_1 and T_a.

(3) Table showing user assignment of pseudo-format numbers.

(4) The final Console/Format Matrix produced by Part I. This matrix contains double entries (N_{ij}'s and T_{ij}'s) in elements defined on a row index i and a column index j. Many of these entries will be zero (whenever an N is zero, the corresponding T will be zero, although the reverse may occasionally not be true, due to rounding of T_{ij}).

The control cards may be of several types. At least some of these cards (the "user cards") contain information supplied by the user of Part II. These user cards are punched from data supplied by the user on a special form to be provided.

The information content of the five types of user cards is specified in Section 4.

2. Operation of DRAP Routines

The general operation of Part II routines has been shown in Figure 1 of the algorithm for Part I, and is discussed there. Part II provides five types of processing: LIST, SUM, LIST/SUM, HIST, and SUM/HIST, any or all of which may be activated by user cards. In addition, any activated process may be required to repeat several times, operating on a different data set each time.

The results, which are printed out in a suitable report format, consist of five types of summary data, corresponding to the five types of processing which can be done.

3. Details of Algorithms

This section discusses the detailed algorithm which must be performed for each of the five types of processing.

3.1 LIST

The purpose of LIST is to list, in the report, all non-zero elements in user-specified rows (values of i) and columns (values of j) of the C/F matrix. The user specifies which of two printout formats is to be used, i.e., whether the data is to be printed out by console or by channel/format. For example, if the matrix has 450 columns and if the user specifies printout by console, row 2 ($i = 2$) and all columns ($j = 0, 1, 2,$ -------449), this processor will search the 2nd row, examining all 450 elements in that row. It will discard all elements for which both N and T are zero, and retain those elements for which $N > 0$. In doing so, it will have satisfied the user's requirement to look at all elements in the 2nd row which also fall into one of the specified columns (all columns, in this case).

For each of those elements (those values of j) having $N > 0$, the LIST processor will convert j to its corresponding MSK format number or non-D/TV channel number, using the table of assignments of j, and store the result (a number with 2 or 4 decimal digits), the value of N (an integer requiring 4 decimal digits), and the value of T (the uptime in hours, requiring 7 decimal digits). T is expressed in decimal fraction form, e.g., 329.2156 hours or

001.0023 hours. A number of these 15-digit packages will be stored, one package for each element having $N > 0$. The final step would be to print out, either then or at the end of the run, the accumulated data. For the above example, and assuming non-zero elements for j = 3, 59, 316, and 317, (channel 49 and formats 0029, 1560, and 1561, respectively, e.g.) the result would be a line of printout:

CON 02 49, N_{23}, T_{23} 0029, $N_{2,59}$ $T_{2,59}$ 1560, $N_{2,316}$, $T_{2,316}$ 1561, $N_{2,317}$, $T_{2,317}$

Under the same conditions, if the user had specified columns 0 through 50, 100 through 200, and 300 through 316, only the first and third items above would be printed out. If the user had, in addition, specified rows 0 and 25, the processor would search all three rows and there would be 3 lines of printout, beginning, respectively, with CON 00, CON 02, and CON 25, and if there had been no non-zero elements in row 25, there would be no data following CON 25. The data for any particular row may take more than one line of printout, of course.

If the user had specified a printout by channel/format, it would appear as follows:

CHAN 49	02, N_{23}, T_{23}
FORMAT 0029	02, $N_{2, 59}$, $T_{2, 59}$
FORMAT 1560	02, $N_{2, 316}$ $T_{2, 316}$
FORMAT 1561	02, $N_{2, 317}$, $T_{2, 317}$

In both the above cases, the actual printout would contain the values of the various N's and T's, rather than their symbols as shown. It is clear that if the user is concerned with the number of lines of data on the printout, he should use care in choosing between the "by console" format and the "by channel/format" format. If the minimum number of printout lines is desired, then he should choose:

(1) The "by console" format, if the number of channels/ formats exceeds the number of consoles (as in the example above).

(2) The "by channel/format" format if the number of consoles exceeds the number of channels/formats.

As a further example, suppose the user had specified the following set of values for i and j:

i's (rows): 0 to 25, 29 to 50, and 54 to 60 (inclusive)

j's (columns): 23 to 23, and 235 to 236 (inclusive),

and had also specified a "by channel/format" printout (as he should, if he wishes to minimize lines of printout). Suppose further that j = 23 corresponds to channel 51, j = 235 to format 1089, and j = 236 to format 1090. The printout would then appear as follows (again, with numerical values in place of the symbols):

```
CHAN 51       00, N0,23, T0,23      01, N1,23, T1,23      02, N2,23T2,23
              03, N, T ----------- 25, N, T              29, N, T
              30, N, T ----------- 50, N, T              54, N, T
              55, N, T ----------- 60, N, T
FORMAT 1089   00, N0,235, T0,235    01, N1,235, T1,235
              02, N, T  03, N, T -----------
              25, N, T  29, N, T -----------
              50, N, T  54, N, T -----------  60, N, T
FORMAT 1090   00, N0,236, T0,236  01, N1,236 T1,236
              02, N, T -------------- 25, N, T        29, N, T
              -----------50, N, T    54, N, T     ----------
              60, N, T
```

Note that the foregoing remarks have mainly to do with the format in which data is printed out. In spite of such remarks as "the processor will search the 2nd row," no restriction on the manner of examining matrix elements is implied. There may well be a most efficient way of examining the matrix in any given case, and this may be related to the printout format specified, but such questions are not addressed here.

Note also that if any of the N's <u>and</u> their associated T's in the foregoing examples had been zero, neither would have been printed out.

3.2 <u>SUM</u>

The purpose of SUM is to add the entries (N's and T's) lying in user-specified rows and columns of the matrix, so as to produce two quantities:

$$S_{IJ} + \sum_{i \text{ in } I} \sum_{j \text{ in } J} N_{ij} = \sum_{I,\, J} N_{ij} \qquad (1)$$

$$U_{IJ} = \sum_{i \text{ in } I} \sum_{j \text{ in } J} T_{ij} = \sum_{I,J} T_{ij} \qquad (2)$$

Here, the notation "I" and "J" has been introduced to symbolically designate the set of i's and the set of j's, respectively, which have been supplied by the user.

The quantity S_{IJ} is the total number of observations of all pseudo-formats (j's) specified in J, by all the consoles (i's) specified in I. The quantity U_{IJ} is the total uptime of all pseudo-formats (j's) specified in J, on the monitors of all consoles (i's) specified in I. In computing these quantities, the SUM processor must search appropriate rows and columns of the matrix, accumulating the two sums as it examines the various elements. As in the case of LIST, it may be desirable to vary the search procedure, but the printout format is always one line, as in the following example.

I 02-02 J 000-449 S_{IJ} 900 U_{IJ} 49.5000

This is seen to be the result of assuming the first example of Section 3.1 (specify row 2, all 450 columns) together with the assumption that all N's have the value 2 and all T's have the value 0.11. Note that, unlike LIST, SUM has no restrictions on whether or not a matrix element is zero; all zero-valued N's and T's get added in even though this does not affect S or U.

The print format could exceed one line for a SUM output, but only if the specifications of I and J were very extensive. The worst case would be to specify every other row and every other column; based on a 62-row by 342-column matrix, this would require the printing of roughly 1244 decimal digits, plus 201 hyphens, 199 commas, 2 alphabetic characters, and 4 spaces, just to list the specified rows and columns. When digits and characters for S and U are added, the result is about 1680 print-columns, or 14 lines of print.

3.3 LIST/SUM

This processor is a modification of the previously described LIST processor, wherein the individual values of N and T are not listed, although the console and channel/format numbers still are. Instead of listing the individual values, these are summed (separately for N and T) for each line of printout, i.e., for each console or for each channel/format. The resulting sums are printed out as TOTAL N or TOTAL T at the start of each line. Such sums could, of course, be obtained by repeated specification of the SUM processor, and the listings of consoles and/or channels/formats could be gotten from a specification of LIST; in this sense, LIST/SUM is a combination of LIST and SUM for use where individual values of N and T are not desired.

The procedure is similar to that for LIST, except that instead of storing individual values of N and T for later printout, these are accumulated and only the sums are printed out.

Referring to the first example for which a printout was given in Section 3.1, the user would specify the same parameters (including "by console" print format) for LIST/SUM, but the printout would appear as follows:

CON 02 TOTAL N 1086 TOTAL T 41.0257 49 0029 1560 1561

In the second example printout of Section 3.1 (specifying printout by channel/format), the result would appear as follows (assumed numbers):

CHAN 49 TOTAL N 500 TOTAL T 28.0100 02

FORMAT 0029 TOTAL N 150 TOTAL T 5.0060 02

FORMAT 1560 TOTAL N 350 TOTAL T 7.0047 02

FORMAT 1561 TOTAL N 86 TOTAL T 1.0050 02

In the third example of Section 3.1, (the"further example") the LIST/SUM printout would have appeared as follows (assuming no zero values for N):

CHAN 51 TOTAL N 520 TOTAL T 3.6801 00 01

02 03 - - - - - - 25 29 30 - - -

50 54 55 - - - - 60

FORMAT 1089 TOTAL N 123 TOTAL T 17.029 00 01

02 03 - - - - - - 25 29 - - - - - - 50

54 - - - - - - 60

FORMAT 1090 TOTAL N 230 TOTAL T 21.644 00 01

02 - - - - - - 25 29 - - - - - - 50 54

- - - - - - 60

Again, any console numbers for which both N and T = 0 would have been omitted from the printout.

3.4 <u>HIST</u>

The purpose of HIST is to produce points (abscissa and ordinates) for a histogram. The data for which the histogram is constructed consists of the numbers N or T found in user-specified matrix elements. This processor will construct a single complete histogram as it examines the specified matrix elements. If the user specifies N, it will construct the histogram using as data only values of N; if the user specifies T, it will construct the histogram using only values of T. If the user wishes both an N-histogram and a

T-histogram, he must specify two separate HIST operations, even though the same I (i-set) and J (j-set) may apply to both. HIST will search the matrix and examine each element implied by I and J. At each element, it will process either the N or the T in that element. At the end of this search-and-process operation, the ordinates for either an N-histogram or for a T-histogram will have been accumulated; these, together with I, J, and abscissa information, are printed out in the report.

Note that there are no restrictions on the allowable values of N or T, as far as HIST is concerned; the value "zero" is quite legitimate for either N or T, and such zero-valued elements must be processed since they contribute to the histogram.

The calculation of abscissa information is identical to that done in DRAP Module 1, p. 7. From the set of N's (or T's) that have been specified, the largest value N_{max} (or T_{max}) will be selected (and printed out), and the number of histogram ranges n determined by rounding off, to the next higher integer, the quantity $\frac{Nmax}{R}$ (or $\frac{Tmax}{R}$), where R is the user-specified histogram range (abscissa increment). For N-histograms, the user-specified value of R will vary from 1 to 500; for T-histograms, R will vary from 000.0100 hours to 036.0000 hours.

The abscissa intervals are from 0 to r_1, r_1 to r_2, r_2 to r_3, -----r_{n-1} to r_n, where $r_n = n\ (R)$ and $r_p = r_{p-1} + R = (p)\ (R)$. The start and stop end points r_p ($p = 0, 1, 2, - - -, n$) must be calculated, and the values of N (or of T) must be allocated to the various ranges. With one exception, a particular N (or T) is allocated to the p^{th} range if

$$r_{p-1} < N \leq r_p \quad (\text{or } r_{p-1} < T \leq r_p) \qquad (3)$$

The one exception is an N (or T) with the value zero; such a value obviously will not be allocated to any of the histogram intervals by (3) above, even for $r_{p-1} = 0$. These zero-valued N's (or T's) are allocated to a special "interval" which has zero width, i.e., the "interval" extending from 0 to 0.

The test for allocation to this interval is $N = 0$ (or $T = 0$).

At the end of the allocation process, the number of N's (or T's) which have been allocated to each interval, (including the "zero interval") are counted to obtain a set of numbers (counts) c_p ($p = 0, 1, 2, - - - -, n$), which are to be printed out along with the values of p and r_p. Note that c_o is the number of N's (or T's) for which $N = o$ (or $T = o$).

Also calculated and printed out are M_1 and M_o, where

$$M_1 = \sum_{p=1}^{n} c_p, \quad M_0 = \sum_{p=0}^{n} c_p = M_1 + c_0 \tag{4}$$

and S_N (or S_T) where

$$S_N = \sum_{I,\, J} N_{ij} \quad \text{and} \quad S_T = \sum_{I,\, J} T_{ij} \tag{5}$$

Note that M_o is just the product of the number of rows specified in I and the number of columns specified in J, while S_N (and S_T) could have been obtained by a separate SUM operation over I and J. A guess as to an upper bound on S_N is 28,000,000; on S_T is 1,400,000.

Also calculated and printed out are the mean values of N (or T) both for inclusion of zeros and exclusion of zeros: $\overline{N}_o$ is the mean value of N if zero values are counted (likewise for $\overline{T}_o$), and N_1 is the mean value of N if they are not (likewise for $\overline{T}_1$). These are calculated by

$$\overline{N}_o = \frac{S_N}{M_o} \quad , \quad \overline{N}_1 = \frac{S_N}{M_1} \tag{6}$$

$$\overline{T}_o = \frac{S_T}{M_o} \quad , \quad \overline{T}_1 = \frac{S_T}{M_1}$$

A guess as to an upper bound on $\overline{N}_1$ is 500,000, although this is not very likely ($\overline{N}_o$ is always less than $\overline{N}_1$). A guess as to an (unlikely) upper bound on $\overline{T}_1$ is 25,000. $\overline{T}_o$ is always less than $\overline{T}_1$.

Since for small values of R, coupled with large values of N_{max} or T_{max}, the number of histogram intervals (and hence the number of c_p's) could be very large (resulting in much printout), it is desirable to printout only those c_p's which are non-zero. The printout format for the p's, r_p's, and c_p's is a set of 3 lines, repeated as necessary (see Section 5.2).

3.5 SUM/HIST

This processor is a modification of HIST, in that the basic data for the histogram is not individual N's and T's but sums of N's and sums of T's. These sums are taken along rows (or partial rows) or along columns (or partial columns) of the C/F matrix, depending on whether the user specifies "sum over channels/formats" or "sum over consoles," respectively. These sums, denoted by S_i or S_j, respectively, are the data from which a histogram (either an N-histogram or a T-histogram) is constructed, using the techniques specified for HIST.

The process will be illustrated by simplified examples, based on the assumed C/F matrix shown in Figure 1. In each element, the upper number is N and the lower number is T.

As in HIST, the user specifies a set of i's and a set of j's. Assume these sets are as follows:

I_1 0 - 4 (inclusive)

J_1 1 - 9 (inclusive)

The set of elements defined by I_1 and J_1 are enclosed by heavy lines on Figure 1. Assume the user has specified a T-histogram and has also specified "sum over channels/formats;" this is interpreted as sum over j's (along rows). For each row in I_1, DRAP will calculate

$$S_i = \sum_{i, J_1} T_{ij} \qquad i = o, 1, 2, 3, 4,$$

i.e., it will calculate

$$S_o = \sum_{i=0, j=1-9} T_{ij}$$

and similarly-defined S_1, S_2, S_3, and S_4.

Referring to the values of T given in Figure 1, it is seen that

$S_o = .1 + 0 + 0 + 0 + 0 + .5 + .4 + .3 + 0 = 1.3$

$S_1 = .2 + 0 + 0 + .1 + .1 + 0 + 0 + .2 + .8 = 1.4$

I_1, J_1

Pseudo-Format (j)

Console (i)	0	1	2	3	4	5	6	7	8	9
0	N = 0 T = 0	N = 2 T = .1	N = 0 T = 0	0 0	0 0	0 0	4 .5	5 .4	5 .3	0 0
1	N = 1 T = 0	N = 3 T = .2	N = 1 T = 0	0 0	1 .1	2 .1	0 0	0 0	1 .2	9 .8
2	N = 1 T = .001	N = 1 T = .1	N = 4 T = .7	0 0	1 0	0 0	7 .8	0 0	4 .6	3 .4
3	0 0	1 .2	0 0	0 0	2 .3	1 .1	5 .4	4 .4	3 .2	7 .7
4	1 .3	2 .1	1 .1	0 0	3 .2	1 .2	3 .3	5 .6	7 .8	9 .9
5	1 .2	0 0	1 0	0 0	2 .2	0 0	10 .9	13 .9	6 .5	11 .9
6	0 0	2 .1	1 .1	0 0	1 .2	0 0	14 .8	10 .8	0 0	15 .9
7	0 0	1 .3	3 .4	0 0	1 0	1 .5	12 .8	13 .9	2 .3	16 .9
8	0 0	0 0	1 .1	0 0	2 .2	0 0	14 .7	17 .9	3 .3	10 .9
9	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0

I_2, J_2

Figure 1

C/F Matrix for SUM/HIST Examples

$S_2 = .1 + .7 + 0 + 0 + 0 + .8 + 0 + .6 + .4 = 2.6$

$S_3 = .2 + 0 + 0 + .3 + .1 + .4 + .4 + .2 + .7 = 2.3$

$S_4 = .1 + .1 + 0 + .2 + .2 + .3 + .6 + .8 + .9 = 3.2$

The numbers S_o, - - - -, S_4 are the data used to construct the histogram. Assume the user has specified a histogram range R of 1.0; DRAP would then select (and printout) S_{max} from the data (the S's), resulting here in $S_{max} = 3.2$. Next, this would be divided by R and rounded to the next higher integer to get n:

$$\frac{3.2}{1} = 3.2 \quad , \quad n = 4$$

Thus there will be 4 intervals on the histogram, plus the "zero interval," corresponding to r_0, r_0 to r_1, r_1 to r_2, r_2 to r_3, and r_3 to r_4. Numerically, these intervals are, respectively, 0, 0 to 1, 1 to 2, 2 to 3, and 3 to 4. The data will then be allocated to these intervals and the number of data falling in each interval will be counted to yield c_p:

interval (p)	data in interval	c_p
0	none	0
1	none	0
2	1.3, 1.4	2
3	2.3, 2.6	2
4	3.2	1

The results (p, r_p, and c_p) would be printed out in three rows:

p	0	1	2	3	4
r_p	0	1	2	3	4
c_p	0	0	2	2	1

If more than three rows of printout result, the first row will be labeled p, the second r_p, the third c_p, and these three labels will then repeat for subsequent rows, with a blank row between each set of three rows. Note that if row 9 had been included in I_1, the sum for that row would be zero, and hence there would have been a count of at least 1 for $p = 0$ (the "zero interval"). Also, note that quantities M_1, M_0, S_T, $\overline{T}_0$, and $\overline{T}_1$ would be calculated and printed out: $M_1 = \sum_{p=1}^{n} c_p = 5$ $\qquad M_0 = \sum_{p=0}^{n} c_p = 5$

$S_T = \sum_{I_1, J_1} T_{ij} = \sum_{I_1} S_i = 10.8$ $\qquad \overline{T}_0 = \frac{S_T}{M_0} = \frac{10.8}{5} = 2.16$

$\overline{T}_1 = \frac{S_T}{M_1} = \frac{10.8}{5} = 2.16$ $\quad M_1$ and M_0 (and hence $\overline{T}_1$ and $\overline{T}_0$) turned out to be equal in this example because it happened that $c_0 = 0$.

As a second example, assume the user specifies an i-set I_2 and a j-set J_2:

I_2 1 - 9 (inclusive) $\qquad J_2$ 2 - 4, 6 - 8 (inclusive)

The matrix elements corresponding to these sets are enclosed by heavy lines in Figure 1.

Assume the user has specified an N-histogram, and has specified "sum over consoles." DRAP would then sum all the N's in column 2 which also fell in rows 1 through 9, thus producing S_j for $j = 2$. In a similar manner, it would produce S_3, S_4, S_6, S_7, and S_8. From the figure, the numerical calculations would be:

$$S_2 = 1 + 4 + 0 + 1 + 1 + 1 + 3 + 1 + 0 = 12$$
$$S_3 = 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 = 0$$
$$S_4 = 1 + 1 + 2 + 3 + 2 + 1 + 1 + 2 + 0 = 13$$
$$S_6 = 0 + 7 + 5 + 3 + 10 + 14 + 12 + 14 + 0 = 65$$
$$S_7 = 0 + 0 + 4 + 5 + 13 + 10 + 13 + 17 + 0 = 62$$
$$S_8 = 1 + 4 + 3 + 7 + 6 + 0 + 2 + 3 + 0 = 26$$

Assume the user had specified a histogram range R of 5. DRAP would then select S_{max} from the set of S_j's (i.e., $S_6 = 65$), divide this by R and round to the next higher integer to get n: $\frac{65}{5} = 13$, $n = 14$

Since $\frac{S_{max}}{R}$ happened to be an integer, the process of rounding to the next higher integer yields the next integer, i.e., 14. The quotient $\frac{S_{max}}{R}$ need be calculated to only one decimal place; enough histogram intervals will be provided, because of the "rounding-up" safety factor, to accommodate all data.

Thus there will be 15 histogram intervals (n = 14 plus the "zero interval"). DRAP will calculate the break-points between these intervals, thus defining intervals:

symbolic	numeric
r_0	0
r_0 to r_1	0 to 5
r_1 to r_2	5 to 10
r_2 to r_3	10 to 15
r_3 to r_4	15 to 20
r_4 to r_5	20 to 25
r_5 to r_6	25 to 30
r_6 to r_7	30 to 35
r_7 to r_8	35 to 40
r_8 to r_9	40 to 45
r_9 to r_{10}	45 to 50
r_{10} to r_{11}	50 to 55
r_{11} to r_{12}	55 to 60
r_{12} to r_{13}	60 to 65
r_{13} to r_{14}	65 to 70

For the zero interval, an S_j is allocated to that interval if $S_j = 0$; for all others, it is allocated to the p^{th} interval if $r_{p-1} < S_j \leq r_p$. The number allocated to each interval is counted, yielding a set of c_p, which, along with p and r_p, are printed out:

p	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
r_p	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70
c_p	1	0	0	2	0	0	1	0	0	0	0	0	0	2	0

The S_j allocated to $p = 0$ is S_3, to $p = 3$ are S_2 and S_4, to $p = 6$ is S_8, and to $p = 13$ are S_7 and S_6. The printout would appear as shown above, in 3 lines labeled, respectively, p, r_p and c_p.

DRAP would next calculate (see Section 3.4)

$$M_1 = \sum_{p=1}^{n} c_p \qquad = 2 + 1 + 2 = 5,$$

$$M_0 = \sum_{p=0}^{n} c_p \qquad = M_1 + c_0 = 5 + 1 = 6,$$

$$S_N = \sum_{i \text{ in } I_2,} \sum_{j \text{ in } J_2} N_{ij} = \sum_{j \text{ in } J_2} S_j \qquad = 12 + 0 + 13 + 65 + 62 + 26 = 178$$

$$\bar{N}_0 = \frac{S_N}{M_0} = \frac{178}{6} = 29.667$$

$$\bar{N}_1 = \frac{S_N}{M_1} = \frac{178}{5} = 35.600,$$

and print these out.

The M's are always integers; an upper bound for M_0 is 500, and M_1 is always less than M_0. An upper bound for S_N is 28,000,000; this number is always an integer. S_T, which is calculated for the first example, is not integral, and must be accurate to the fourth decimal place (ten-thousandth of an hour). An upper bound on S_T is 1,400,000. The $\bar{N}$'s must be calculated to 3 decimal places. An upper bound on $\bar{N}_1$ is 400,000; $\bar{N}_0$ is always less than $\bar{N}_1$. An approximate upper bound on $\bar{T}_1$ is 25,000; $\bar{T}_0$ is always less than $\bar{T}_1$.

The S_j's and S_i's calculated in SUM/HIST are integral if an N-histogram is being calculated, with an upper bound of 480,000 on a given S_j and an upper bound of 4,000,000 on any S_i. If a T-histogram is being calculated, the S_j's and S_i's are not integral, and must be accurate to 4 decimal places; they have upper bounds, respectively, of 180,000 and 23,000.

To summarize, the sequence of operations for SUM/HIST are

(1) The user specifies I and J, "sum over consoles" or "sum over channels/formats," and whether he wants an N-histogram or a T-histogram. He also specifies R.

(2) DRAP calculates sums S_i (if "sum over channels/formats" is specified) <u>or</u> sums S_j (if "sum over consoles" is specified). These are sums of N's if an N-histogram is specified and they are sums of T's if a T-histogram is specified.

(3) DRAP finds S_{imax} (or S_{jmax}, as the case may be) and divides this number by R, rounding to the next higher integer to obtain n, the number of non-zero-width histogram intervals. A zero-width "interval" is always added to the set of intervals, the complete set is identified by p = 0, 1, 2, - - - -, n.

(4) The end-points of the intervals are calculated.

(5) The S_j's (or S_i's, as the case may be) are allocated to the intervals, using an equality test to allocate for p = 0 and an inequality to allocate for $p \neq 0$.

(6) The number of sums allocated to the intervals are counted to obtain a set of counts c_p.

(7) Numbers M_1 and M_0 are calculated.

(8) A number S_N (or S_T, as the case may be) is calculated by summing the S_j's (or S_i's, as the case may be).

(9) Numbers $\overline{N}_0$ and $\overline{N}_1$ are calculated, using S_N and M_0 or M_1 (or $\overline{T}_0$ and $\overline{T}_1$ are calculated, using S_T and M_0 or M_1, as the case may be).

(10) The values of p, r_p & c_p are printed out, as are S_{max} and the numbers found in (7) through (9) above. In addition, the I and J specified by the user is printed out.

Note that the value of R specified by the user may vary from 1 to 500 for an N-histogram and from .1 to 360 for a T-histogram.

4. Information Supplied on User Cards

The user of DRAP 6, Part II, must supply, on a suitable form, information which is punched into cards (user cards) for input along with the tape produced in Part I.

The user must specify which of the five Part II processors are to operate (if any of these are to operate more than once, he must make multiple specifications). For each specification of a processor, the user must specify the data-set (I and J) to be used for that particular operation of the processor. In addition to the name of the processor and the data-set, various parameters of the calculation must be specified, the particular parameters and their allowable values being dependent on which processor is being used.

Below are shown the data required from the user for each of the processors, together with allowable values or choices, where appropriate.

Name	Data Set	Other Specifications/Choices
LIST	I and J	By console <u>or</u> by channel/format
SUM	I and J	
LIST/SUM	I and J	By console <u>or</u> by channel/format
HIST	I and J	N-histogram <u>or</u> T-histogram
		R (from 1 to 500 for N-histogram, from 0.01 to 36.0 for T-histogram)
SUM/HIST	I and J	N-histogram <u>or</u> T-histogram
		sum over channels/formats <u>or</u> sum over consoles
		R (from 1 to 500 for N-histogram, from 0.1 to 360 for T-histogram)

The data set will be specified separately for I and J, giving in each case the (included) end-points of one or more continuous sequences of values of i (or j). For example, an i-set might be specified by

I 00 — 03, 08 — 08, 40 — 50,

implying consoles 00 to 03 (inclusive), console 08, and consoles 40 to 50 (inclusive). Thus a total of 16 consoles would have been specified, in terms of their decimal addresses.

To continue the example, a j-set might be specified by

J 001 — 042, 131 — 178, 272 — 272,

implying pseudo-format numbers (values of j) 001 through 042 (inclusive), 131 through 178 (inclusive), and 272. Depending on the user assignment of these j's to non-D/TV channels and/or display formats (as identified by MSK number) these j's might represent VSM input channels 29 through 70, formats 0602 through 0773 (the EECOM formats for GT-8; not a continuous sequence of numbers, note), and format 1450 (the Recovery and Weather format for GT-8). Thus a total of 42 channels and 49 formats would have been specified.

It can be seen from the foregoing table that a LIST operation can be specified in either of two different ways, a SUM operation in only one way, a LIST/SUM operation in one of two ways, a HIST operation in one of two ways, and a SUM/HIST operation in one of four ways, <u>not counting</u> the various possible combinations of values for I, J, and R.

It is suggested that the forms provided the user for specifying his choices be in the nature of a separate page(s) for each operation, i.e., that there be a page format set up for LIST, a different one for SUM, one for LIST/SUM, etc. It is further suggested that the user be able to make any binary choices (such as between "by console" and "by channel/format") by placing a check mark in one of two labeled boxes. By way of illustration, the page format for SUM/HIST might be arranged as shown on the last page of this section; this format includes both boxes to be checked and blanks to be filled in. Provision should be made for the user to make multiple specifications for each processor, as shown for SUM/HIST.

SUM/HIST

From	To	From	To	Sum Over (Check One)	Type Histogram (Check One)	Value of R (Specify one value. Use range of values corresponding to box checked in previous column)
____	____	____	____			
____	____	____	____	☐ Channels/formats	☐ N	(1 to 500)
____	____	____	____			________
____	____	____	____			
____	____	____	____	☐ Consoles	☐ T	(0.1 to 360.0)
____	____	____	____			
____	____	____	____			
____	____	____	____	☐ Channels/formats	☐ N	(1 to 500)
____	____	____	____			________
____	____	____	____			
____	____	____	____	☐ Consoles	☐ T	(0.1 to 360.0)
____	____	____	____			
____	____	____	____			
____	____	____	____	☐ Channels/formats	☐ N	(1 to 500)
____	____	____	____			________
____	____	____	____			
____	____	____	____	☐ Consoles	☐ T	(0.1 to 360.0)
____	____	____	____			
____	____	____	____			
____	____	____	____	☐ Channels/formats	☐ N	(1 to 500)
____	____	____	____			________
____	____	____	____	☐ Consoles	☐ T	(0.1 to 360.0)
____	____	____	____			

5. Suggested Report Format

5.1 Header Information

The data to be filled in (in underlined blank spaces) was either specified by the user for Part I or calculated by Part I; all of it was input to Part II as part of the data on the matrix tape.

DATA RETRIEVAL AND ANALYSIS PROGRAM (DRAP)

DRAP MODULE 6 REPORT - GENERALIZED CONSOLE/FORMAT ANALYSIS. PART II - CONSOLE/FORMAT USAGE DATA.

MISSION__________ GMTS__________ GMTF__________

T_a__________ANALYSIS TIME N_1__________D/TV CHANNELS

USER ASSIGNMENT OF PSEUDO-FORMAT NUMBERS

CHANNEL OR FORMAT	J
__________	____
__________	____
__________	____
__________	____
__________	____
__________	____
⋮	⋮

5.2 Summary Data

Specific examples of print format are given for each processor, in Section 3. Below, a sample of printout is given for each processor, using symbolic abbreviations. Note that the symbols I and J represent, in each case, sets of number-pairs; these sets may be quite extensive. Where binary choices have been made by the user, (see Section 4) one of the alternatives is shown, with the other alternative in parentheses; only the chosen one is actually printed, of course. The format below assumes that each processor was specified once, but any set of the processors may be specified, each one any number of times. Hence the printout may have many repetitions of each processor (there might be 20 sections labeled HIST, e.g., with a full set of data for each). The number of lines needed to print the data for any particular specified operation will vary over a wide range. Note that part of the data to be printed below is specified by the user of Part II (name of processor, I, J, R, N or T, BY CON or BY CHAN/FORM, SUM OVER CHAN/FORMAT or SUM OVER CON); the rest is calculated data. The symbol "j_c" represents a value of j which has been converted to a channel number or a format number via the table giving the user assignment of pseudo-format numbers. The symbol "i" represents a console decimal address, "N" represents a value of N, "T" a value of T, etc.

```
LIST    I   ____, ____     ____, ____     ____, ____     - - - - - -
        J   ____, ____     ____, ____     ____, ____     - - - - - -
        BY CON (BY CHAN/FORM)
        CON ____      jc, N, T       jc, N, T       jc, N, T - - - - -
        CON ____      jc, N, T       - - - - -
        etc.
        (CHAN ____    i, N, T       i, N, T       i, N, T  - - - - - -)
        (FORM ____    i, N, T - - - - - - - - - - - - - - - - - - - - )
        etc.
SUM     I   ____, ____     ____, ____     - - - - - - - -
        J   ____, ____     ____, ____     - - - - - - - -
        SIJ ______________________ OBSERVATIONS
        UIJ ______________________ HOURS UPTIME
```

HIST I (as above)

J (" ")

N (T) HISTOGRAM

R ____________

M1 ____________ M0 ____________

SN ____________ OBS (ST ____________ HRS)

$\overline{N0}$ ____________ OBS ($\overline{T0}$ ____________ HRS)

$\overline{N1}$ ____________ OBS ($\overline{T1}$ ____________ HRS)

P	0	1	2	3	4 - - - - - - -	n
RP	0	r_1	r_2	r_3	r_4- - - - - - -	r_n
CP	c_0	c_1	c_2	c_3	c_4- - - - - - -	c_n

LIST/SUM I (as above)

J (" ")

BY CON (BY CHAN/FORM)

CON _____ TOTAL N _____OBS TOTAL T _______HRS

j_c j_c j_c j_c - - - - - -

(CHAN _____ TOTAL N _____OBS TOTAL T _______HRS

i i i i - - - - -)

(FORM _____ TOTAL N _____OBS TOTAL T _______HRS

i i i i - - - - -)

SUM/HIST	I	(as above)				
	J	(" ")				
	N	(T) HISTOGRAM				

SUM OVR CHAN/FORM (SUM OVR CON)

SMAX ______________OBS (HRS)

M1 ___________ MO ____________

SN ___________OBS (ST _____________HRS)

$\overline{NO}$ ___________OBS ($\overline{TO}$ ______________HRS)

$\overline{N1}$ ___________OBS ($\overline{T1}$ ______________HRS)

P	0	1	2	- - - - - - -	n
RP	0	r_1	r_2	- - - - - - -	r_n
CP	c_0	c_1	c_2	- - - - - - -	c_n

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